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ABSTRACT

This document contains supplemental materials for special needs high school students intended to facilitate their mainstreaming in regular auto mechanics courses. Teacher's materials precede the materials for students and include general notes for the instructor, suggestions, 18 references, a class progress chart, a questionnaire on the usefulness of the supplemental materials, and an answer key to student work sheets. The student materials consist of 10 color-coded instructional units on the following topics: using service and shop manuals; safety, preventive maintenance inspection; checking tire and wheel runout and tire balancing; checking and repairing shock absorbers; checking and replacing MacPherson struts; using meters to test wiring and switches; testing a charging system; testing the cranking system; and troubleshooting an electronic ignition system. The units are self-paced and contain simplified line drawings, controlled text, vocabulary development, and math practice exercises. The units typically include the following materials: (1) an introduction; (2) the objective of the unit; (3) the objectives on which students will be assessed; (4) terms and pictures of equipment used in the unit and on the job; (5) verbal and illustrated step-by-step explanations of a skill or task; (6) skill sheets that contain paper and pencil exercises that develop and reinforce math skills; (7) activity sheets designed to increase student involvement and provide extra skill practice; (8) unit reviews involving identification, matching, multiple-choice, and short-answer exercises; and (9) checklists on which to evaluate student performance. (CML)

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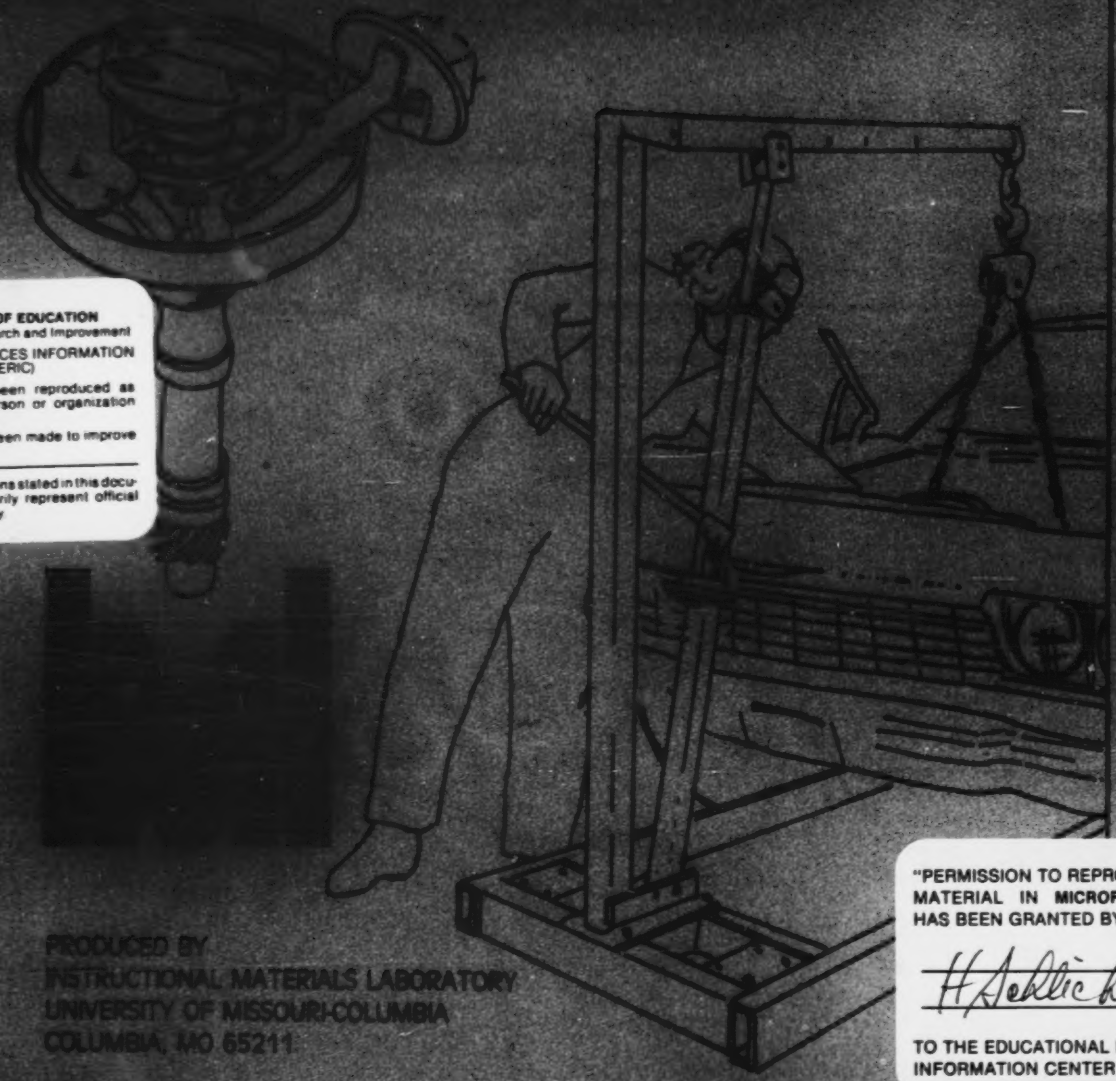
Auto Mechanics



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Supplementary Units

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Supplementary Units for

Auto Mechanics

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Columbia, Missouri

August 1988

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Supplementary Units for

Auto Mechanics

Table of Contents

Preface iv
Acknowledgements v
General Notes to the Instructor vii
Bibliography vii
Follow-up Questionnaire ix
Class Progress Chart xi
Answer Keys xiii

Auto Mechanics Units

Using Service and Shop Manuals . . . . Unit 1
Introduction: Safety . . . . Unit 2
Preventive Maintenance Inspection . . . . Unit 3
Checking Tire and Wheel Runout and Tire Balancing . . . . Unit 4
Checking and Repairing Shock Absorbers . . . . Unit 5
Checking and Replacing MacPherson Struts . . . . Unit 6
Using Meters to Test Wiring and Switches . . . . Unit 7
Testing a Charging System . . . . Unit 8
Testing the Cranking System . . . . Unit 9
Trouble-shooting an Electronic Ignition System . . . . Unit 10

Supplementary Units for

Auto Mechanics

Preface

Auto Mechanics Supplementary Units are a Special Needs curriculum project sponsored by the Missouri Department of Elementary and Secondary Education, Vocational Special Needs Education. The purpose of this project is to provide supplementary materials for special needs students enrolled in regular welding courses.

The special needs units should facilitate the mainstreaming of students with a wide variety of handicapping and disadvantaged conditions. These units are self-paced and contain simplified line drawings, controlled text, vocabulary development and math practice exercises. Each unit is color-coded as follows:

White:	Introduction, Objectives and Student Assessment -- This page presents unit and specific objectives the student must meet to successfully complete the unit. The introduction contains a brief motivational statement describing the purpose and content of the unit. Student Assessment allows the student to determine whether to study the material in the unit or move directly to the unit exam.
Salmon:	Terms and Equipment -- This section introduces new terms and equipment necessary for the student to understand and perform the tasks shown in the unit.
Canary:	Steps of Procedure -- this presents a verbal and illustrated step-by-step explanation of a given skill or task.
Green:	Skill Sheets -- These pages provide paper and pencil exercises to develop and reinforce the math skills necessary to perform the procedures in the unit.
Blue:	Activity Sheets -- Various activities are presented to increase student involvement and provide extra practice in performing the procedures.
Pink:	Unit Review and Performance Checklist -- These sheets are used by the instructor to evaluate student performance. Different forms of review, including identification, matching, multiple-choice and short answer exercises are provided.

These units were developed as hands-on procedural materials for the special needs student and as a resource and guideline to assist the instructor. The instructor's responsibility will be to adapt the material to suit a particular teaching/learning situation. This material can be used as a resource for a variety of special learning situations.

"Instructor's information," located in the front of the book, contains notes to the instructor, helpful resources and answer keys.

Supplementary Units for

Auto Mechanics

Acknowledgements

This Auto Mechanics supplementary guide results from the efforts of the following individuals:

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Supplementary Units for

Auto Mechanics

General Notes to the Instructor

Step 1: Read through the information in each unit before presenting it to the student.

Step 2: Make sure all equipment to be used in each unit is available.

Step 3: Prepare any handouts, visuals or supplemental material to aid student learning activities.

Step 4: Provide the student with the Introduction page.

Step 5: Discuss the tasks on the Introduction page and give directions for completing the "Are You Ready?" section.

Step 6: Have the student complete the Introduction page.

Step 7: If the student elects to complete the Unit Review and Performance Checklist and does so to your satisfaction, have him or her proceed to the next step.

Step 8: Discuss the Introduction page information with the student. At this time you can also discuss the Terms and Equipment lists.

Step 9: Provide the student with the Steps of Procedure section.

Step 10: Select a means to present the Steps of Procedure. (The means will depend on the student.) You might choose to:

a. Have the student study the information independently.
b. Go through the Steps of procedure individually or as a group.
c. Go through the material as a group; then have students work independently.

Step 11: Demonstrate the procedures to the student or class.

Step 12: Give the student time to practice the procedure. (You, the instructor, decide how much time they need.)

Step 13: Have the student complete all the skill sheets for the unit. Skill Sheets reinforce skills necessary to perform the procedures in the unit and may be used by the student as a self-evaluation tool or by the class as a discussion aid.

Step 14: Complete any applicable activities listed on the Activity Sheets.

Step 15: When the student is ready, use the Unit Review and Performance Checklist to evaluate the student's performance for that unit.

Supplementary Units for

Auto Mechanics

Additional Suggestions

Try a team approach when possible:

--Beginning students can work together after the instructor's demonstrations.

--One student with experience in the procedure can work with a beginner.

For non-readers or ESL students, audio-visuals of the lessons can be prepared.

Review equipment with students whenever necessary.

Each exercise can be used as a pencil and paper exercise or in any way you, the instructor, feel will best help to clarify the material.

Additional modifications can be made to take care of other disadvantaged/handicapped conditions unique to your situation.

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Webster, Jay. Auto Mechanics. Glencoe Publishing Co., 1980.

Special Needs Follow-Up Questionnaire

Staff members, writers and advisors have worked to make these instructional materials easy--both to use and to read. We welcome your suggestions and/or corrections. Please return this questionnaire with your comments to:

Special Needs Editor
Instructional Materials Laboratory
10 Industrial Education Building
University of Missouri-Columbia
Columbia, Missouri 65211

Thank you for your time and consideration.

Supplementary Units for

Auto Mechanics

My overall rating of this publication is:

Excellent Very Good Good Fair Poor

To improve the materials, IML should:

Other Comments:

Optional:

Name: ______________________

Address: ______________________

Auto Mechanics

Class Progress Chart

									STUDENT NAMES
									WHAT THE STUDENT CAN DO
									Use service and shop manuals
									Comply with safety rules
									Perform preventive maintenance inspection
									Check tire and wheel runout and balance tires
									Check and repair shocks
									Check and repair struts
									Use meters to test wiring and switches
									Test charging system
									Test cranking system
									Trouble-shoot an electronic ignition system

Instructor's Signature/Date ____________________

AUTO MECHANICS

USING SHOP MANUALS

ANSWER KEY

Skill Sheet 1

1. table of contents
2. glossary
3. appendix
4. index
5. table of contents
6. index, glossary
7. glossary
8. table of contents, index

Activity Sheet 1

Answers will vary depending upon reference supplied by the instructor.

Skill Sheet 2

Decide what information you need.
Decide which reference is likely to contain the information.
Look up the information in the reference.
Read the information.
Apply the information to the job being done.

Skill Sheet 3

1. 1982-1983
2. 15.4 Gallons
3. 9.4 Quarts
4. This model is turbo-charged.
5. 6 3/4" Ring and Pinion 2.5 Pints
   7 1/2" Ring and Pinion 3.5 Pints

Skill Sheet 4

1. .035
2. 1,8,4,3,6,5,7,2
3. 12°
4. Before Top Dead Center
5. 580 N
6. Neutral

Unit Review

1. table of contents
2. glossary
3. appendix
4. index
5. rows
6. columns
7. a. 3
   b. 2
   c. 5
   d. 1
   e. 4

Answers

SKILL SHEET 1

1. a
2. False
3. b
4. True
5. d
6. Class A -- solids
   Class B -- liquids
   Class C -- electrical parts
   Class D -- metals

UNIT REVIEW

1. True
2. False
3. True
4. False
5. True
6. False
7. True
8. True
9. True
10. False

ANSWER KEY

Skill Sheet 1

1. not O.K.
2. are not
3. is
4. hot
5. do not

Skill Sheet 2

1. a. threads
   b. "o"-ring gasket
   c. size
2. is
3. not
4. do not use
5. as soon as possible

Unit Review

1. A
2. B
3. True
4. False
5. True

ANSWER KEY

Skill Sheet 1

1. car
2. Imbalance
3. (answer depends on your shop)
4. is not
5. necessary

Skill Sheet 2

1. will
2. is not
3. a. measure the tread depth
   b. examine the tread for unusual wear patterns
   c. examine the tread and side wall for cracks or knots
4. should

Unit Review

1. a
2. a
3. TRUE
4. TRUE
5. FALSE
6. TRUE
7. c
8. TRUE
9. b
10. FALSE

ANSWER KEY

Skill Sheet 1
1. will
2. gas shock absorber
3. hydraulic
4. stiff
5. bounce test

Skill Sheet 2
1. will
2. bad
3. 8-12
4. normal
5. a. body language
   b. bent or rusted rod
   c. defective rubber bushings
   d. broken or cracked mount

Skill Sheet 3
1. front pair of
2. front
3. purge
4. rear
5. grommet

Unit Review
1. A
2. D
3. B
4. B
5. D

AUTO MECHANICS
STRUTS

Answer Key

Skill Sheet 1

1. will
2. is
3. 8-12
4. is
5. does

Skill Sheet 2

1. upper
2. both
3. not okay
4. is
5. must

Skill Sheet 3

1. should
2. after
3. does
4. is
5. should not

Unit Review

1. A
2. A
3. A
4. D
5. B

AUTO MECHANICS
USING METERS

ANSWER KEY

SKILL SHEET 1

1. parallel
2. series-parallel
3. series
4. series
5. parallel

SKILL SHEET 2

1. ammeter
2. ohmmeter
3. analog
4. voltmeter
5. ohmmeter

SKILL SHEET 3

1. battery
2. load device
3. open
4. negative
5. positive

SKILL SHEET 4

1. break or open
2. negative
3. open
4. on
5. negative

SKILL SHEET 5

1. resistance
2. battery
3. zero
4. infinite
5. low

SKILL SHEET 6

1. open
2. positive
3. parallel
4. range
5. battery

SKILL SHEET 7

1. series
2. positive
3. circuit
4. range
5. power

UNIT REVIEW

1. a
2. true
3. true
4. true
5. true

ANSWER KEY

SKILL SHEET 1
1. does
2. are
3. must
4. can
5. is

SKILL SHEET 2
1. should not
2. 12
3. regulator
4. 16
5. regulator

SKILL SHEET 3
1. does
2. must
3. is not
4. is
5. could

UNIT REVIEW
1. a
2. b
3. d
4. a
5. FALSE

ANSWER KEY

SKILL SHEET 1
1. rotate
2. control
3. neutral safety switch
4. solenoid
5. 30 seconds

SKILL SHEET 2
1. should
2. negative
3. 200-250 9.6-10.2
   150-175 9.6-10.2
   125-150 9.6-10.2
4. 0.5 volts
   0.2 volts
   0.3 volts

UNIT REVIEW
1. TRUE
2. a
3. a
4. c
5. d

ANSWER KEY

SKILL SHEET 1

1. rotor
2. control module
3. induction
4. centrifugal
5. low

UNIT REVIEW

1. FALSE
2. c
3. b
4. b
5. d

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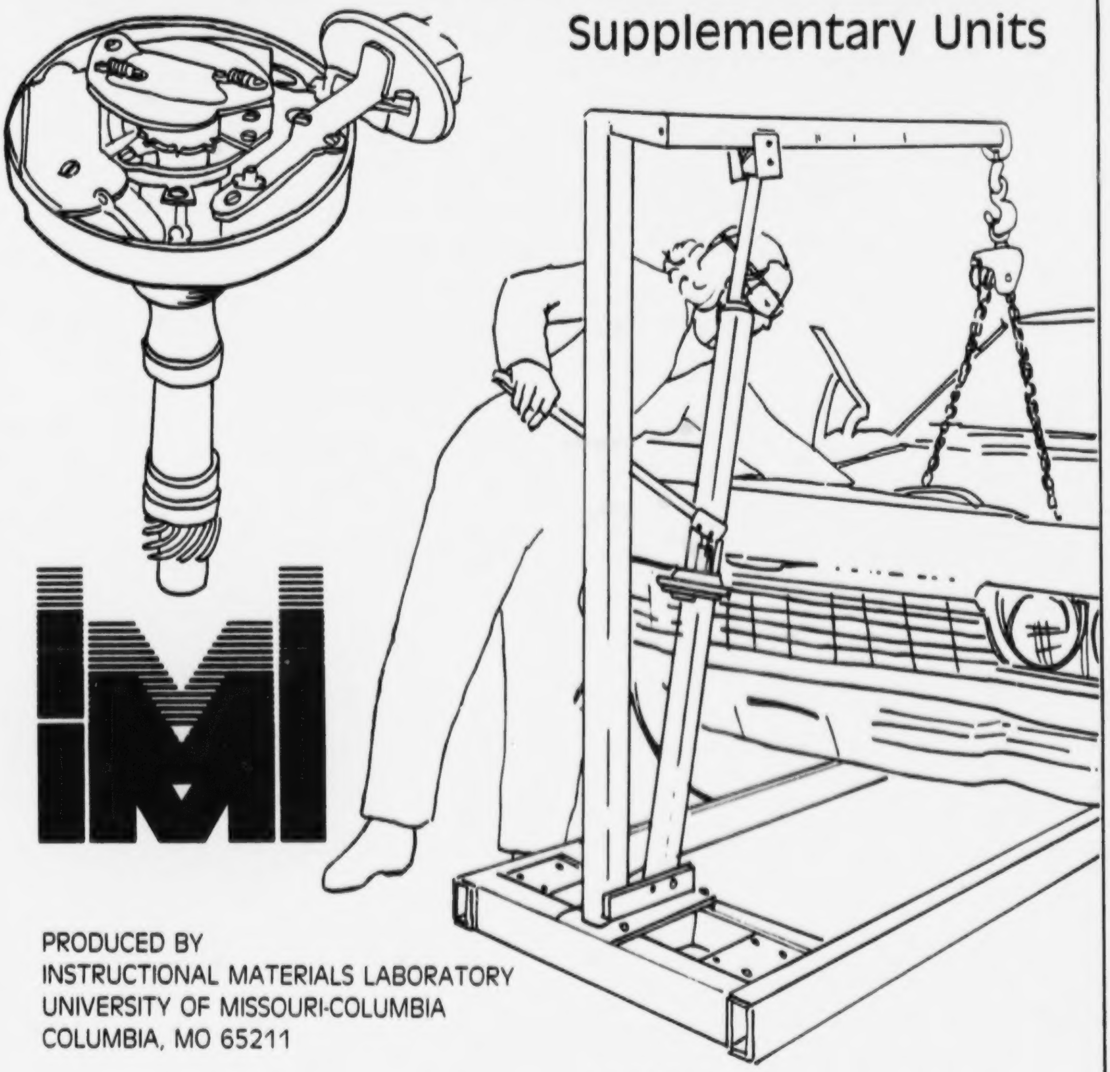
Auto Mechanics

Supplementary Units



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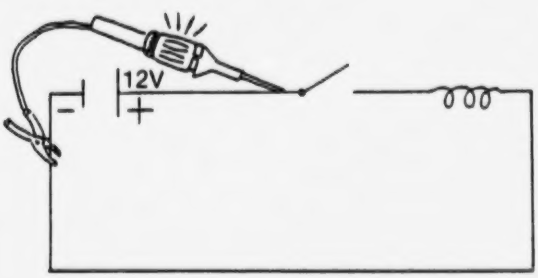

Unit 1

Using Service and Shop Manuals

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2

USING SERVICE AND SHOP MANUALS

INTRODUCTION

Today's automobiles are made of many parts that, when joined together, form complex assemblies or systems. Without up-to-date manuals, correct and cost-efficient repair of these assemblies and systems would be very hard.

The mechanic must be able to read and understand the manuals. The manuals can be one of the most important tools in the shop. Most manuals include specifications, service procedures and diagnostic information.

UNIT OBJECTIVE

After studying this unit, you will be able to locate and use information in service manuals.

SPECIFIC OBJECTIVES

After studying this unit, you will be able to specifically:

1. Recognize and use important parts of reference books.
2. List the steps for locating information in references.
3. Locate correct repair service or shop manual information.
4. Use reference charts and tables.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Appendix** - a reference section that contains extra information at the end of a book.

2. **Chart** - a reference that contains information listed in rows and columns.

3. **Columns** - the up-and-down (vertical) grid lines of information on a table or chart.

4. **Glossary** - an alphabetical list of terms and their meanings (definitions) usually found at the back of a book.

5. **Index** - an alphabetical list of the important subjects in a book. Usually at the back of a book, the index gives page numbers where specific words appear in the text.

6. **Reference** - any book, report, chart, cassette, film, etc. that gives helpful information.

7. **Rows** - the left-to-right (horizontal) grid lines of information in a table or chart.

8. **Table** - an organized list of information (usually in columns and rows); also called a chart.

9. **Table of contents** - the section of a book, usually at the front, that lists the book's chapters in order and shows each chapter's beginning page number.

10. **Specification** - a statement that gives detailed and exact information about materials, specifications and procedures for repairs or service.

11. **Original equipment** - replacement components and parts, usually available from the dealer, that are exactly the same as those used when the car was new.

12. **After market equipment** - replacement components and parts that are designed, built and supplied by companies other than the original car maker.

13. **Flat rate manual** - a book for mechanics, also known as an estimator guide, that estimates the time, the labor costs, the parts needed and the cost of parts for each type of repair job. When billing a customer, a mechanic usually bases the charges for parts and labor on the manual's prices.

14. **Manufacturer's Shop Manual** - a book written by a car manufacturer that describes, in great detail, repair procedures and specifications for the company's cars. The manuals often come in several volumes and usually cover one model and year. Because the manuals are written for experienced mechanics, publishers often use them as a source from which to write service manuals.

15. **Owner's Manual** - a book that comes with a new car and tells the owner how to use, maintain and care for the car.

16. **Repair manual** - a book, written by an after market company, that gives repair procedures and specifications for several car models. The repair manual often covers more than one year's models in a single volume.

17. **Service bulletin** - a short bulletin that usually deals with one or two topics and is used by car manufacturers to keep mechanics up-to-date. Items commonly found in service bulletins are:

    - Corrections of information in shop manuals
    - Improved procedures for specific repair jobs
    - Updates on the parts list
    - Information about product recalls

B. Recognizing and Using the Parts of a Reference Book

A service or repair manual often includes such sections as a table of contents, index, appendix and/or glossary to help you find information quickly and easily. Larger books may include all of these sections, but smaller books may have only a table of contents.

The Table of Contents

1. You can use the table of contents to find information in a book.

2. The table of contents lists the book's chapters or sections in order. The table of contents also gives at least the beginning page number for each chapter or section.

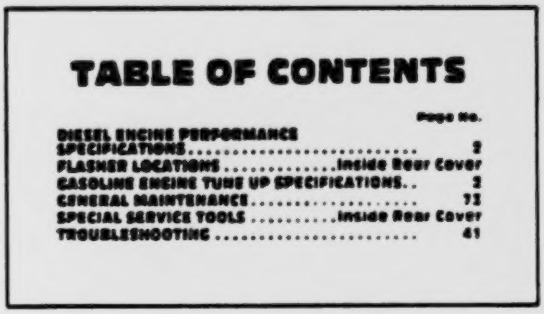


TABLE OF CONTENTS

Page No.

DIESEL ENGINE PERFORMANCE SPECIFICATIONS............................ 2
FLASHER LOCATIONS ....Inside Rear Cover
GASOLINE ENGINE TUNE UP SPECIFICATIONS.. 2
GENERAL MAINTENANCE.................... 73
SPECIAL SERVICE TOOLS ....Inside Rear Cover
TROUBLESHOOTING 41

3. Often a table of contents lists important subjects covered in each chapter. It might also list pictures, charts and other items included in the book.

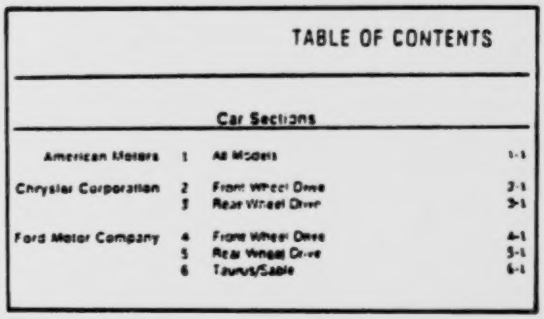
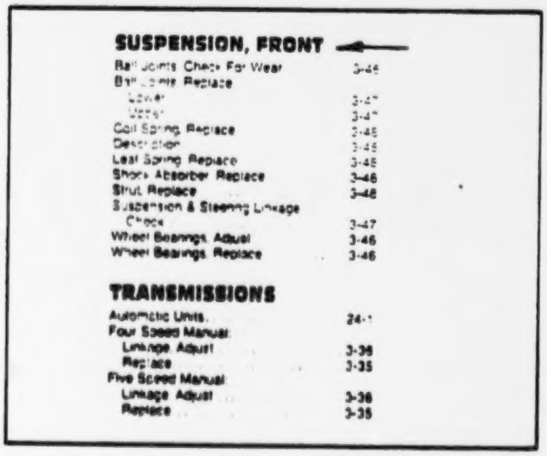


TABLE OF CONTENTS

Car Sections

American Motors	1	All Models	1-1
Chrysler Corporation	2	Front Wheel Drive	2-1
	3	Rear Wheel Drive	3-1
Ford Motor Company	4	Front Wheel Drive	4-1
	5	Rear Wheel Drive	5-1
	6	Taurus/Sable	6-1

4. Often the table of contents tells the pages on which a section, chapter, picture, chart, etc. can be found.



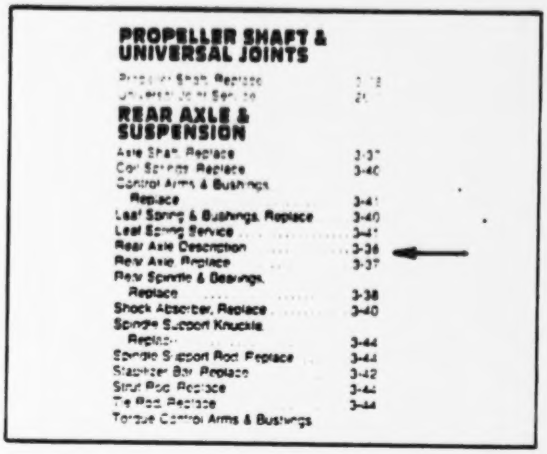
SUSPENSION, FRONT

Ball Joints Check For Wear	3-46
Ball Joints Replace	
Lower	3-47
Upper	3-47
Coil Spring Replace	3-45
Description	3-45
Leaf Spring Replace	3-45
Shock Absorber Replace	3-46
Strut Replace	3-46
Suspension & Steering Linkage Check	3-47
Wheel Bearings Adjust	3-46
Wheel Bearings Replace	3-46

TRANSMISSIONS

Automatic Units	24-1
Four Speed Manual:	
Linkage Adjust	3-36
Replace	3-35
Five Speed Manual:	
Linkage Adjust	3-36
Replace	3-35

5. To use the table of contents, skim through the list until you find the item you need. Then turn to the page number given.



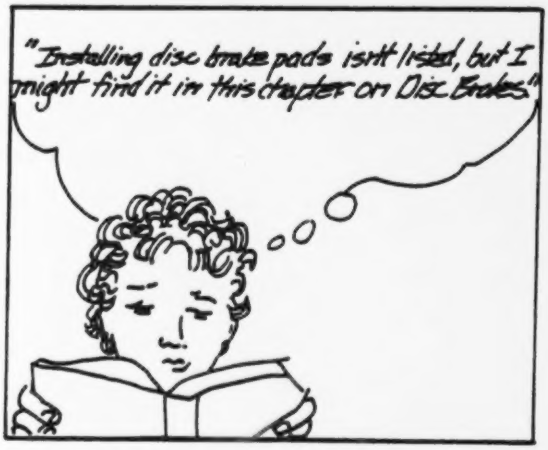
PROPELLER SHAFT & UNIVERSAL JOINTS

Propeller Shaft Replace	[illegible]
Universal Joint Service	[illegible]

REAR AXLE & SUSPENSION

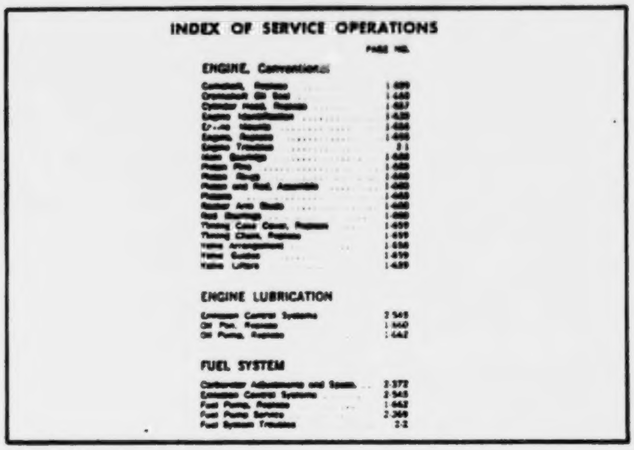
Axle Shaft Replace	3-37
Coil Springs Replace	3-40
Control Arms & Bushings Replace	3-41
Leaf Spring & Bushings Replace	3-40
Leaf Spring Service	3-41
Rear Axle Description	3-36
Rear Axle Replace	3-37
Rear Spindle & Bearings Replace	3-38
Shock Absorber, Replace	3-40
Spindle Support Knuckle Replace	3-44
Spindle Support Rod Replace	3-44
Stabilizer Bar Replace	3-42
Strut Rod Replace	3-44
Tie Rod Replace	3-44
Torque Control Arms & Bushings	

6. Sometimes the item you are looking for might not be listed in the table of contents. In this case, look for the chapter or section that most likely includes the information you need.


"Installing disc brake pads isn't listed, but I might find it in this chapter on Disc Brakes"

The Index

7. You can use the index to find information in a book.



INDEX OF SERVICE OPERATIONS

PAGE NO.

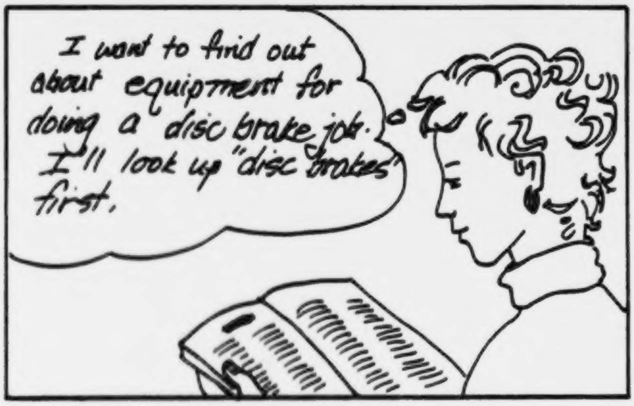
ENGINE, Conventional

ENGINE LUBRICATION

FUEL SYSTEM

8. The index lists subjects covered in a book and tells the page or pages on which the subject is mentioned.

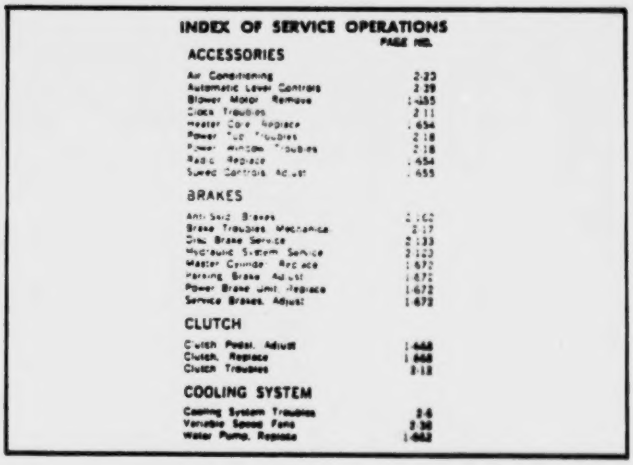
In the index, subjects are listed in alphabetical order.


I want to find out about equipment for doing a "disc brake job." I'll look up "disc brakes" first.

9. To use the index, decide on the word or words that best describe the information you want to find.

10. Looking through the listings, which are in alphabetical order, find the word or words that best describe your subject. Then turn to the page indicated.

Sometimes, you will need to think of several related words and look for them before you find the subject you want.



INDEX OF SERVICE OPERATIONS

	PAGE NO.
ACCESSORIES	
Air Conditioning	2-23
Automatic Level Controls	2-39
Blower Motor, Remove	1-455
Clock Troubles	2-11
Heater Core, Replace	1-654
Power Top Troubles	2-18
Power Window Troubles	2-18
Radio, Replace	1-454
Speed Controls, Adjust	1-455
BRAKES	
Anti-Skid Brakes	2-162
Brake Troubles, Mechanical	2-17
Disc Brake Service	2-133
Hydraulic System Service	2-123
Master Cylinder, Replace	1-672
Parking Brake, Adjust	1-672
Power Brake Unit, Replace	1-672
Service Brakes, Adjust	1-672
CLUTCH	
Clutch Pedal, Adjust	1-448
Clutch, Replace	1-448
Clutch Troubles	2-12
COOLING SYSTEM	
Cooling System Troubles	2-6
Variable Speed Fans	2-38
Water Pump, Replace	1-462

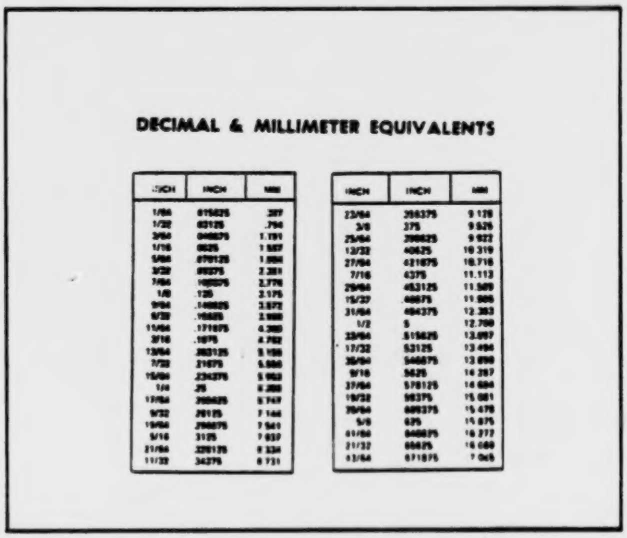
The Appendix

11. An appendix contains extra information added at the back of the book. Usually an appendix includes helpful information that does not fit into the chapters of the book.

"A measurement conversion chart might be in the appendix at the back of the book!"

12. An appendix might have information such as abbreviations, types of measurement or tables that show how to convert from one type of measurement to another.

13. Information in an appendix is often shown in the form of a list, chart or table.

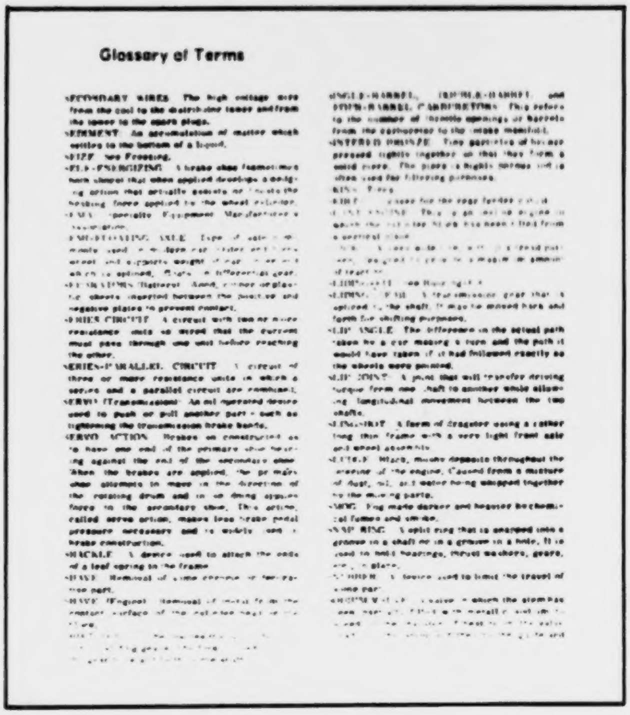


DECIMAL & MILLIMETER EQUIVALENTS

The Glossary

14. Some books also have a glossary at the end. A glossary is an alphabetical list of terms and their meanings (definitions).

    A glossary for an auto mechanics book might include the meanings of difficult terms used in the book or used by mechanics.



Glossary of Terms

BEST COPY AVAILABLE

15. When using a reference book, you may find words you do not recognize or understand.

If you look up these words in a glossary or in the dictionary, you will understand them better and begin to use them more.

(NOTE: If your textbook does not have a glossary, you might want to ask your instructor to recommend a good technical dictionary for auto mechanics. A paperback auto mechanics dictionary or book of terms would be less expensive than a large dictionary.)

"Some of these terms are new to me— I'd better look them up."

DO SKILL SHEET, 1
DO ACTIVITY SHEET 1

SKILL SHEET 1

RECOGNIZING PARTS OF REFERENCE BOOKS

Directions: Answer the questions below by telling which section of a reference book is most helpful in the situation given. The parts of a book are listed for you and may be used more than once.

glossary   index   appendix   table of contents

1. Where should you look to find a list of the chapters in a book?

2. Where should you look in a reference to find the meaning of a new term?

3. Where can you look to find extra information not covered in the main part of the book?

4. Where would you look in a book to find out the page on which a particular subject is discussed?

5. Which part of the book lists things in the order they appear in the book?

6. Which two parts of a book usually list things in alphabetical order?

7. Which part of a book is like a small dictionary?

8. Which two parts tell where things can be found in a book?

USING PARTS OF REFERENCE BOOKS

ACTIVITY SHEET 1

Directions: Using an automotive service manual or textbook provided by your instructor, answer the questions below. You will need to use what you have learned about the parts of reference books to find the answers. If you answer "yes" to a question, write the number of the page on which the part or information can be found in the book.

1. Does the book have a unit on "engines"? ______________

2. Does the book have a chapter on "front wheel drive transmissions" (could also be called "transaxles")? ______________

3. Is there information in the book on "troubleshooting"?

   ____

4. Is there information in the book on setting air pressure in the tires?

   ____

5. Does the book have a glossary? __________________

6. Does the book have more than one index? ________ If your answer is "yes," tell what kinds of indexes are in the book.

   ____

   ____

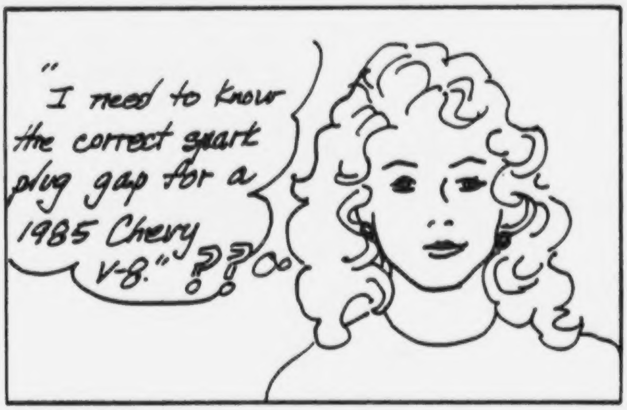
7. Does the book have an appendix? ____________________

If your answer is "yes," tell what kind of information is in the appendix.

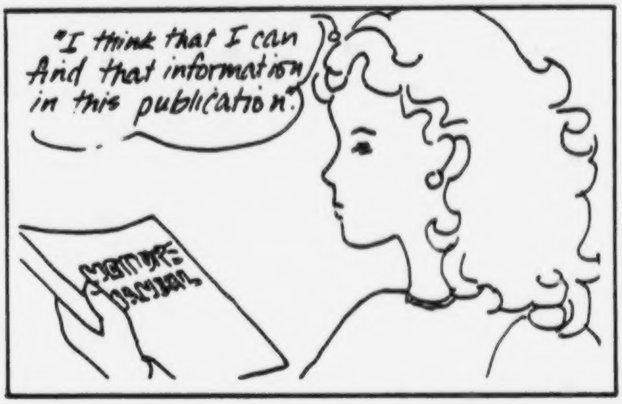
8. Do you think the book is arranged so it is easy to use? ____
If you answer "no," tell how the book could be improved.
If you answer "yes," tell what part of the book you find most helpful and why.

C. Five Steps for Using References

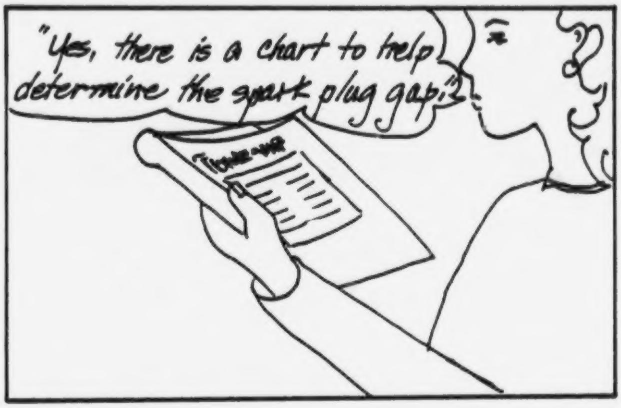
1. Decide what information you need.


"I need to know the correct spark plug gap for a 1985 Chevy V-8."

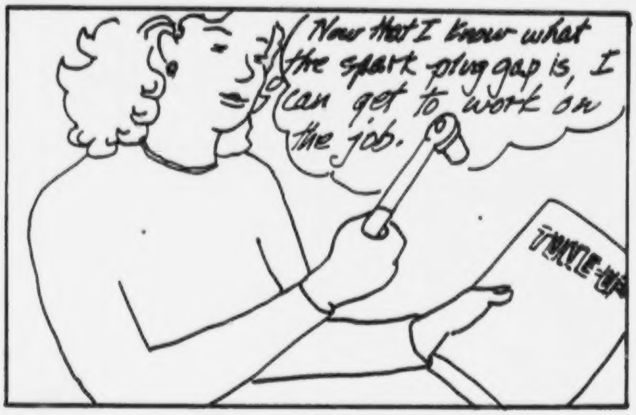
2. Decide which reference is likely to contain the information you need.


"I think that I can find that information in this publication."

3. Look up the information in the reference.


"Yes, there is a chart to help determine the spark plug gap."

4. Read the information.


Now that I know what the spark plug gap is, I can get to work on the job.
TUNE-UP

5. Apply the information to the job being done.

D. Following the Five Steps for Using Service Manuals

Here's an example that shows how the five steps for using references can be followed to find and use helpful information.

Don is getting ready to replace the disc brake pads on his 1985 Chevrolet. He has never done this before and is not sure how to get the caliper and old disc brake pads off. Because he is not sure how to safely and correctly do the job, he will have to use a service manual to find the information.

Let's follow Don through the five steps of using a reference to locate the information he needs.

1. Decide what information is needed.

   Don needs to know how to change his disc brake pads.

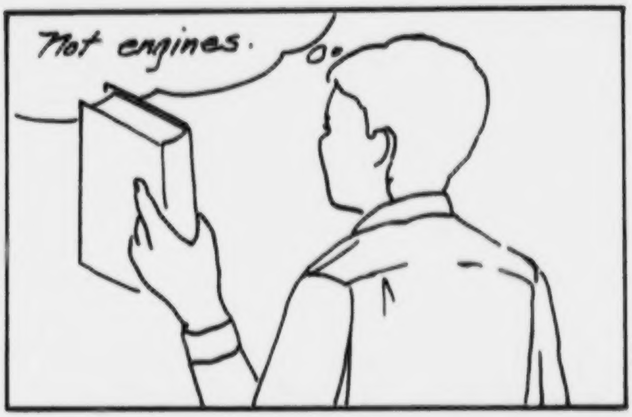
2. Decide which reference is likely to contain the information you need.

   Many service manuals are available, but Don does not have time to look through all of them. He must eliminate references that are not likely to contain the information he needs.

Here is how Don decides which reference he wants:

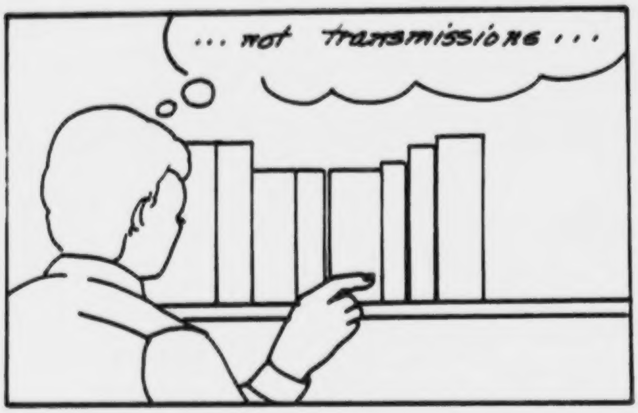
- First, Don eliminates all references that do not deal with brakes.

  (He gets rid of an engine service manual because it will probably not contain information on disc brakes.)


Not engines.

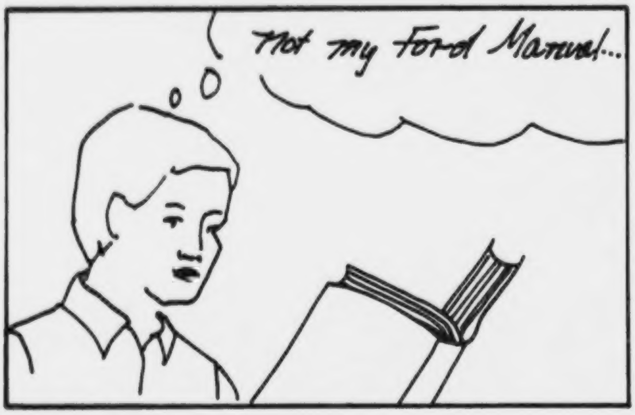
- Second, Don eliminates all references that do not deal with brakes.

  (He puts back a transmission service manual because it probably does not contain information on disc brakes.)

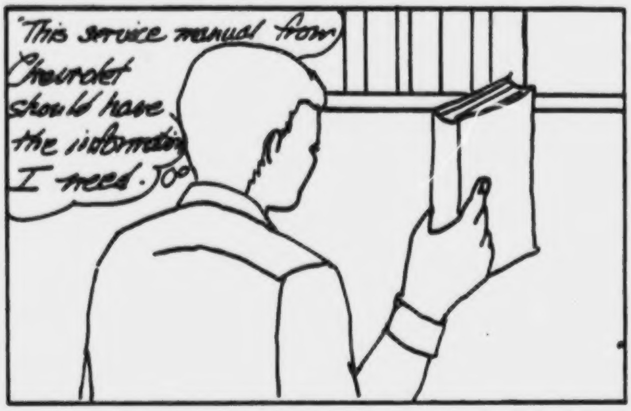

... not transmissions ...

- Third, Don eliminates all references that deal with disc brakes on other car models.

  (He passes over a Ford service manual because it is not likely to contain information on Chevrolet disc brakes.)


Not my Ford Manual...

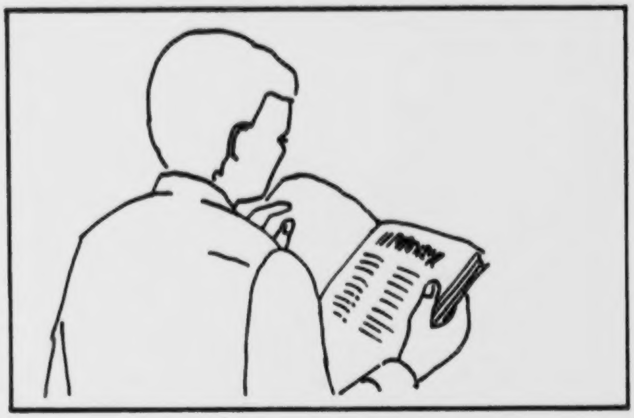
When Don completes this process, he has found a reference that most likely contains the needed information.


"This service manual from Chevrolet should have the informati I need.

3. Look up the information in the service manual.

- **Don does not have time to look through the entire service manual to find the information he wants. He must find the information quickly so he can get on with the brake job.**

- **In this case, the best way to find information quickly is to use the index. Don looks up "disc brakes" in the index to find the page that mentions the needed information.**



- **Don turns to the page indicated in the index and finds the information he needs.**

4. Read the information.

   Don reads the information carefully, double checks confusing passages and heads confidently out to fix the car.

5. Apply the information to the job being done.

   Now Don knows the correct procedure to use when changing the disc brake pads on his car.

6. Now you have seen an example of how to use a reference. If you can follow these steps when using reference materials, you will be a better mechanic.

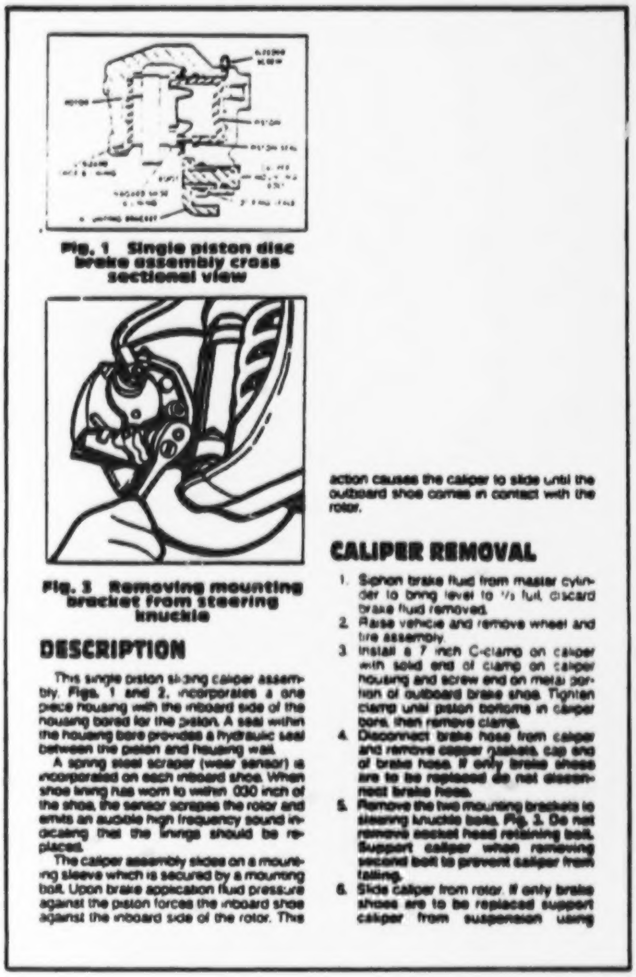


Fig. 1 Single piston disc brake assembly cross sectional view

Fig. 3 Removing mounting bracket from steering knuckle

DESCRIPTION

This single piston sliding caliper assembly, Figs. 1 and 2, incorporates a one piece housing with the inboard side of the housing bored for the piston. A seal within the housing bore provides a hydraulic seal between the piston and housing wall.

A spring steel scraper (wear sensor) is incorporated on each inboard shoe. When shoe lining has worn to within 030 inch of the shoe, the sensor scrapes the rotor and emits an audible high frequency sound indicating that the linings should be replaced.

The caliper assembly slides on a mounting sleeve which is secured by a mounting bolt. Upon brake application fluid pressure against the piston forces the inboard shoe against the inboard side of the rotor. This action causes the caliper to slide until the outboard shoe comes in contact with the rotor.

CALIPER REMOVAL

1. Siphon brake fluid from master cylinder to bring level to 1/3 full, discard brake fluid removed.
2. Raise vehicle and remove wheel and tire assembly.
3. Install a 7 inch C-clamp on caliper with solid end of clamp on caliper housing and screw end on metal portion of outboard brake shoe. Tighten clamp until piston bottoms in caliper bore, then remove clamp.
4. Disconnect brake hose from caliper and remove copper gaskets, cap end of brake hose. If only brake shoes are to be replaced do not disconnect brake hose.
5. Remove the two mounting brackets to steering knuckle bolts, Fig. 3. Do not remove socket head retaining bolt. Support caliper when removing second bolt to prevent caliper from falling.
6. Slide caliper from rotor. If only brake shoes are to be replaced support caliper from suspension using

7. Remember the steps:
   a. Decide what information is needed.
   b. Decide which reference is likely to contain the information needed.
   c. Look up the information in the reference.
   d. Read the information.
   e. Apply the information to the job being done.

DO SKILL SHEET 2
DO ACTIVITY SHEET 2

SKILL SHEET 2

FINDING USEFUL INFORMATION

Directions: Below is a list of the steps to be followed in finding and using reference information, but the list is out of order. Write the list over again in the correct order.

Look up the information in the service manual.

Decide which service manual is likely to contain the information.

Apply the information to the job being done.

Decide what information you need.

Read the information.

1. ____
2. ____
3. ____
4. ____
5. ____

ACTIVITY SHEET 2

FINDING INFORMATION IN A SERVICE MANUAL

Directions: Using the service manuals in your class, find the answers to the following questions. Write the answers in the spaces provided.

1. What is the tightening specification for the spark plugs in a 1985 Chevrolet with a 305 cubic inch V-8 engine?

   ____

2. One eighth (1/8 or .125) of an inch is equivalent to how many millimeters?

   ____

3. Tell where information about changing the front coil springs on a 1982 Ford LTD can be found.

   manual ______________________
   section ______________
   page _____

4. The car you are working on is a 1983 Pontiac. Your boss has asked you to look up how many amps its alternator will produce. Looking at the alternator, you find the part number to be 1100239. Using the year, model and alternator part number, can you find the rated hot ampere output?

   Ampere output __________________

5. You are working on a 1988 Ford Tempo. Your boss has told you to install the tire and properly torque the wheel's lug nuts. What is the lug nut torque specification?

Lug nut torque specification ____________________

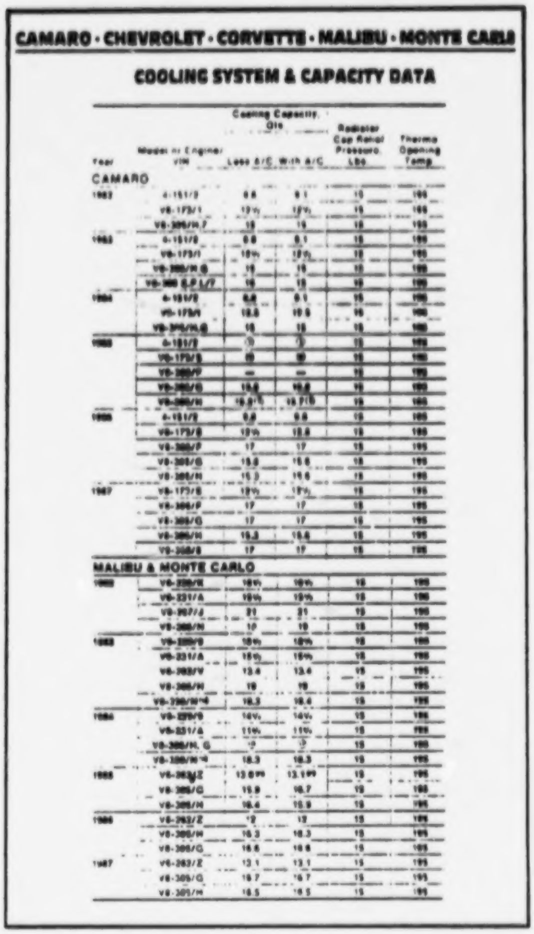
E. Steps of Procedure for Using Charts or Tables

Much of the information a mechanic needs is printed in tables. A table, also called a chart, is an efficient way to show a large amount of information in a small amount of space because it lists information in rows and columns. A mechanic must know how to interpret this information.

1. Charts and tables list information in rows (across) and columns (up and down).

   - Each row has a title or heading that tells what information the row contains.

   - Likewise, each column also has a title or heading that tells what information the column contains.



CAMARO · CHEVROLET · CORVETTE · MALIBU · MONTE CARLO

COOLING SYSTEM & CAPACITY DATA

2. To find information on a chart or table:

   - Find the row with the heading for the type of information you need.

- Using your finger or a ruler, follow the row across the page until you come to the column you need.

  (Look at the heading to be sure you have the column for the type of information you need.)

Don's brother, Roger, who is also a mechanic, needs to find a correct castor angle setting for a 1984 Capri.

Here is how he reads the table to find the information he needs:

- He finds the proper year and model.

WHEEL ALIGNMENT SPECIFICATIONS

Year	Model	Caster Angle, Degrees		Camber Angle Degrees				Toe-in Inch	Toe-Out on Turns, Deg.	
		Limits	Desired	Limits		Desired			Outer Wheel	Inner Wheel
				Left	Right	Left	Right			
1982	Capri & Mustang	+⅜ to +1⅞	+1⅛	−½ to +1	−½ to +1	+¼	+¼	3/16	19.84	20
1983	Capri & Mustang	+½ to +2	+1¼	−¾ to +¾	−¾ to +¾	Zero	Zero	3/16	19.84	20
1984	Capri & Mustang	+½ to +2	+1¼	−¾ to +¾	−¾ to +¾	Zero	Zero	3/16	19.84	20
	Mustang SVO	+⅛ to +1⅞	+1	−¾ to +¾	−¾ to +¾	Zero	Zero	⅛	19.84	20
1985-88	All	+¼ to +1¾	+1	−¾ to +¾	−¾ to +¾	Zero	Zero	3/16	19.84	20

- He follows the row from left to right until his finger is under the column with the heading "Caster Angle, Degrees."

The table gives him two choices: "Limits" or "Desired." Since he was asked for the correct castor angle, he selects the specification under "Desired."

DO SKILL SHEETS 3 and 4

SKILL SHEET 3

Directions: Use the reference chart below to answer each question in the space provided.

FORD MUSTANG & MERCURY CAPRI
COOLING SYSTEM & CAPACITY DATA

Year	Model or Engine/VIN	Cooling Capacity, Qts.		Radiator Cap Relief Pressure, Lbs.	Thermo. Opening Temp.	Fuel Tank Gals.	Engine Oil Refill Qts.①	Transmission Oil			Rear Axle Oil Pints
		Less A/C	With A/C					4 Speed Pints	5 Speed Pints	Auto. Trans. Qts.②	
1982	4-140/A	8.6	9.4	⑦	191	15.4	4	2.8	3.7	8	⑧
	6-200/B	8.4	8.4	16	196	15.4	4	—	—	⑤	⑧
	V8-255/D	14.7	15	16	191	15.4	4⑥	—	—	11	⑧
	V8-302 H.O./F	13.1	13.4	16	196	15.4	4⑥	4.5	—	—	⑧
1983	4-140/A③	8.6	9.4	⑦	191	15.4	4	2.8	—	8	⑩
	4-140/W④	10.5	10.5	⑦	191	15.4	4	—	5.6	—	⑩
	V6-232/3	—	—	16	196	15.4	4	—	—	11	⑩
	V8-302/F	13.1	13.4	16	196	15.4	4⑥	4.5	—	—	3.5

①–Add 1 qt. with filter change unless otherwise noted.
②–Approximate. Make final check with dipstick.
③–Non-turbocharged.
④–Turbocharged.
⑤–C3, 8 qts.; C4 trans., 10 qts.
⑥–Dual sump oil. When draining oil, it is necessary to remove both drain plugs. One drain plug is located at front of oil pan. The second plug is located on left side of oil pan.

1. Which model years can this chart be used for? ____________________

2. How many gallons of gasoline will a 1983 Mustang with a V6-232/3 engine hold? ____________

3. What is the cooling system capacity of a 1983 Capri with a 4 cyl. 140/A engine, without A/C? ____________

4. What important information does **NOTE 4** tell you? ____________

____

5. How many pints of rear axle oil does a 1982 Capri with a 6 cyl./200B engine and 7 1.2" ring gear axle require? ____________________

SKILL SHEET 4

Directions: Use the chart to find tune-up specifications for a 1983 Chrysler with a V8-318/N EFI engine.

CHRYSLER GASOLINE ENGINE PERFORMANCE SPECIFICATIONS

Year & Engine/VIN Code	Spark Plug Gap	Ignition Timing BTDC①				Curb Idle Speed		Fast Idle Speed		Fuel Pump Pressure
		Firing Order Fig.	Man. Trans.	Auto. Trans.	Mark Fig.	Man. Trans.	Auto. Trans.②	Man. Trans.	Auto. Trans.	
1982										
6-225/E Exc. Calif.	.035	B	—	12°	D	—	675N	—	1600④	4-5½
6-225/E Calif.	.035	B	—	12°	D	—	725N	—	1600④	4-5½
V8-318/K 2 Barrel	.035	C	—	16°	A	—	680N	—	1400④	5¾-7¼
V8-318/M 4 Barrel	.035	C	—	16°	A	—	680N	—	1400④	5¾-7¼
V8-318/J E.F.I.	.035	C	—	12°	A	—	580N	—	—	7¼-11¼③
1983										
6-225/H	.035	B	—	16°	D	—	750N	—	2000④	4-5½
V8-318/P 2 Barrel	.035	C	—	16°	A	—	700N	—	1400④	5¾-7¼
V8-318/N E.F.I.	.035	C	—	12°	A	—	580N	—	—	7¼-11¼③
1984										
V8-318/P 2 Barrel Exc. Calif.	.035	C	—	16°	A	—	700N	—	1400④	5¾-7¼
V8-318/P 2 Barrel Calif.	.035	C	—	16°	A	—	730N	—	1400④	5¾-7¼
V8-318/R 4 Bbl.	.035	C	—	16°	A	—	700N	—	1400④	5¾-7¼

①—BTDC-Before top dead center.
②—N: Neutral. D: Drive.
③—In-tank electric fuel pump.
④—With stop screw on second highest step of fast idle cam.

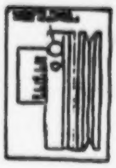


Fig. A

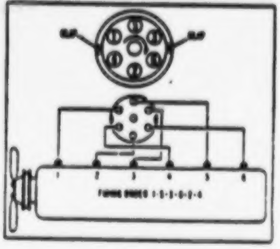


Fig. B

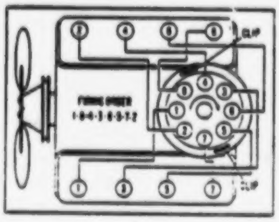


Fig. C

Fig. D

1. What should the spark plug gap be? ________________

2. Write out the ignition firing order starting with cylinder Number 1.

1 __ __ __ __ __ __ __

3. What is the ignition timing specification?

____

4. What does BTDC stand for?

____

5. What is the curb idle speed?

____

6. What does the "N" in the curb idle speed specification stand for?

____

UNIT REVIEW

Directions: Fill in the blanks with the term that best completes each sentence. A list of terms is provided below.

appendix
index
column
rows
table of contents
glossary

1. A list of chapters is shown at the front of a book, in the

   ____.

2. If you want to know what a word means, you can look it up in

   the ____________________________.

3. Helpful extra information can be found at the back of a book,

   in the ____________________________.

4. To quickly find where information is located in a book, you

   can look up the subject in the ______________,

   which is in the back of the book.

5. Lines in a table or chart that go from left to right are called

   ____.

6. Lines in a table or chart that go up and down are called

   ____.

7. **Directions:** Below is a list of the steps to be followed when finding and using reference information, but the list is out of order. Write "1" beside the first step, "2" beside the second step and so on, to show the order in which the steps should be followed.

a. _____ Look up the information in the reference.
b. _____ Decide which reference is likely to contain the information.
c. _____ Apply the information to the job being done.
d. _____ Decide what information you need.
e. _____ Read the information.

PERFORMANCE CHECKLIST

Student ________________________ successfully performed the following tasks:

Task		Yes	No	Comments
1.	Recognized and used important parts of reference books:			
	a. Table of Contents			
	b. Index			
	c. Appendix			
	d. Glossary/Dictionary			
2.	Located information in reference books:			
	a. Decided what information was needed			
	b. Decided what reference might contain needed information			
	c. Looked up information in the reference			
	d. Read the information			
	e. Applied the information			
3.	Used reference charts and tables to find information			

Satisfactory - should move on ☐
Should repeat this unit ☐

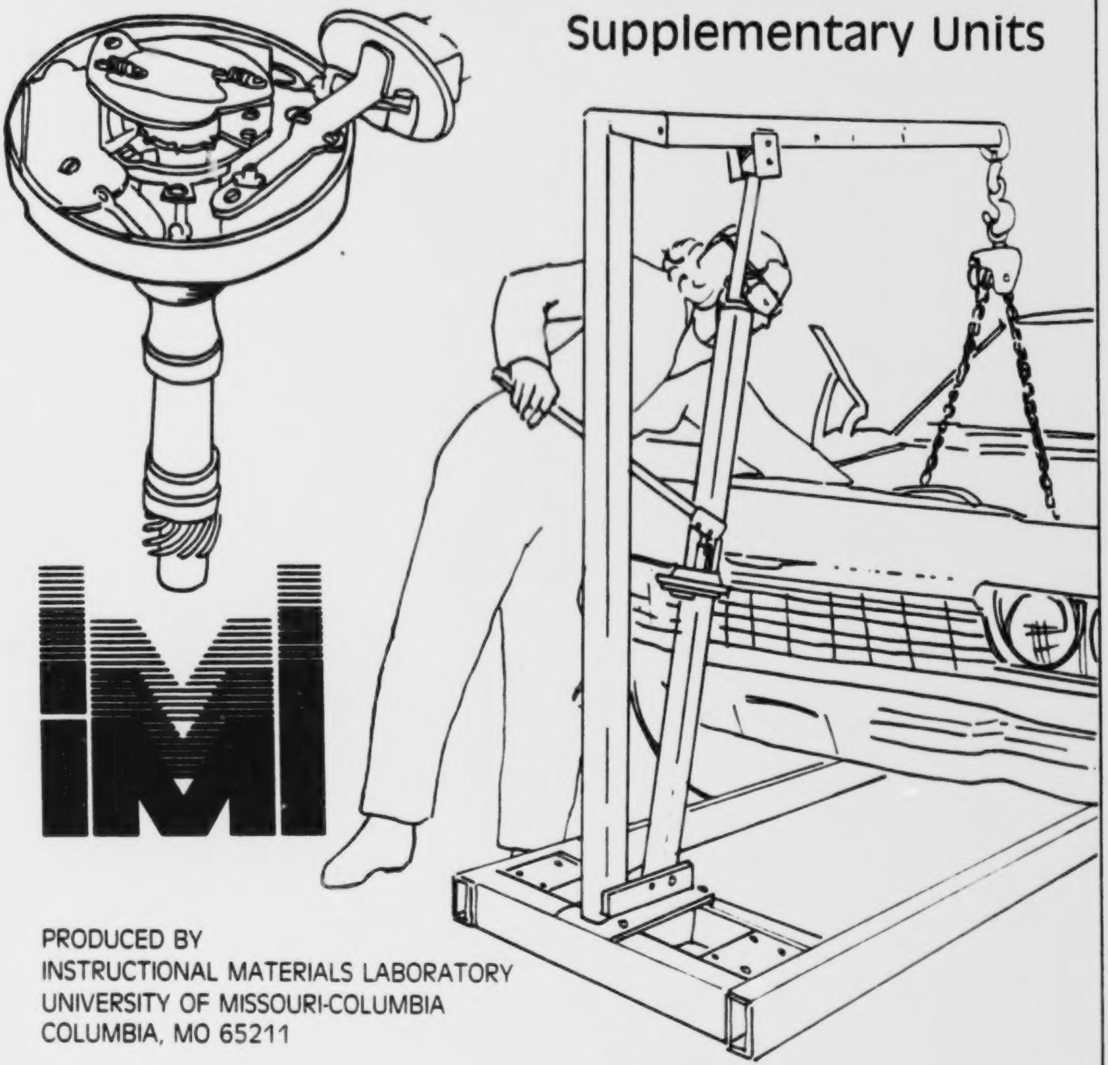
____
Student's Signature/Date

____
Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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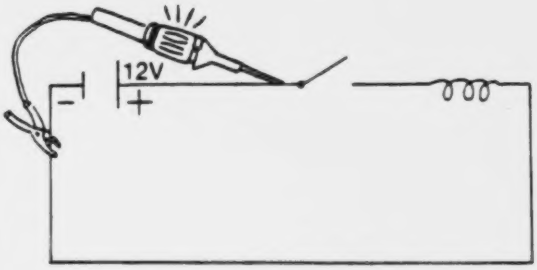

Unit 2

Introduction: Safety

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AUTO MECHANICS

INTRODUCTION: SAFETY

Each year, many people get hurt while working on cars. But car repair does not have to be unsafe. You can prevent most accidents by following shop safety rules and thinking about shop safety.

UNIT OBJECTIVE

After completing this unit, you will have learned how to work as safely as possible in the shop.

SPECIFIC OBJECTIVES

After studying this unit, you will be able to:

1. Recognize common hazards in the use of hand and power tools.
2. Identify hazards and improper use of air and hydraulic equipment.
3. Explain how fires are prevented and put out.
4. Describe the special hazards of automobile work.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms for this Unit

1. **Compressed air** - air whose volume has been made smaller by pressure. Used to power tools, inflate tires and spray paint.

2. **Arc welding equipment** - the tools needed for electric welding; in arc welding, an electric current is used to create the heat needed to fuse pieces of metal together.

3. **Hydraulic hoist** - a device that lifts engine components by means of "hydraulics," the science of moving fluids.

4. **Hydraulic jack** - device that lifts a whole car by means of hydraulics.

5. **Oxygen-acetyiene welding equipment** - welding tools that combine two gases into a mixture that is hot enough to fuse pieces of metal together.

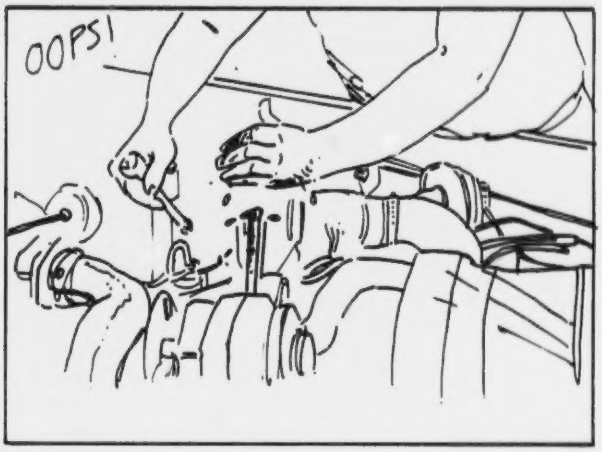
B. Safety Procedures for Working with Tools

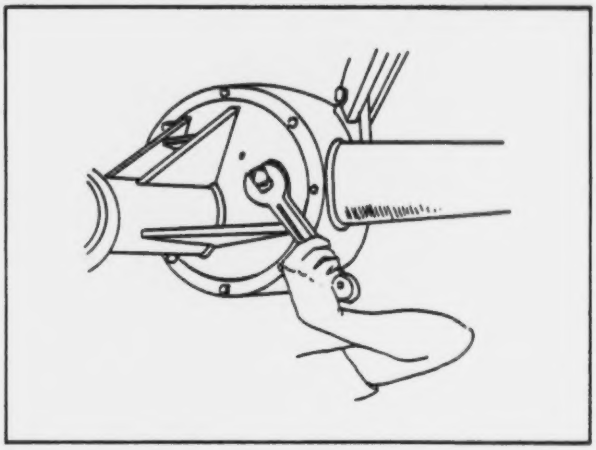
1. Hand tools

Accidents are often caused by careless use of hand tools. Greasy tools can slip out of the hand, fall into the moving parts of an engine, fly out of the engine and injure someone. Tools with sharp edges may cut the user if the tools are not held properly.

The following rules should be observed when using hand tools:

- Keep your hands and tools free of dirt, grease and oil.
- Use the proper type and size of tool for the job.
- Make sure the tool you use is in good working condition.





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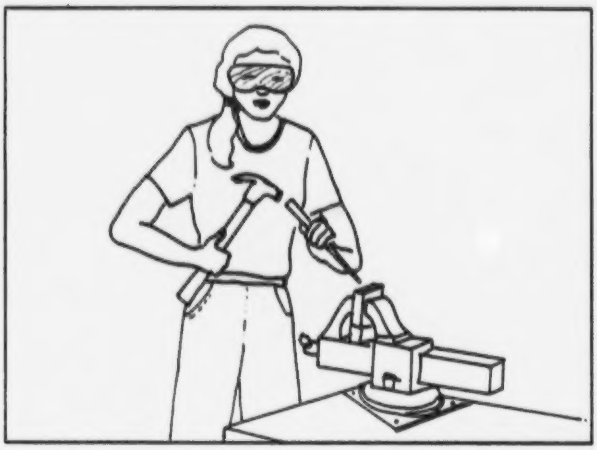
- Point sharp edges of tools away from yourself and fellow workers.

- Clamp small work on a bench, or secure it in a vise, when using chiseling tools.



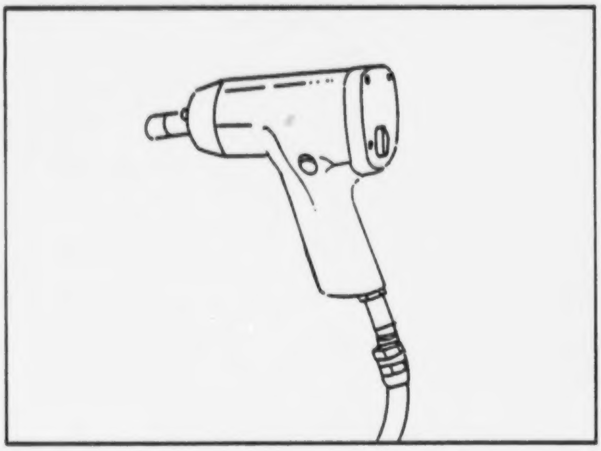
- Wear safety glasses always. When chipping, grinding or cutting metal, place work so flying chips don't hit other workers.

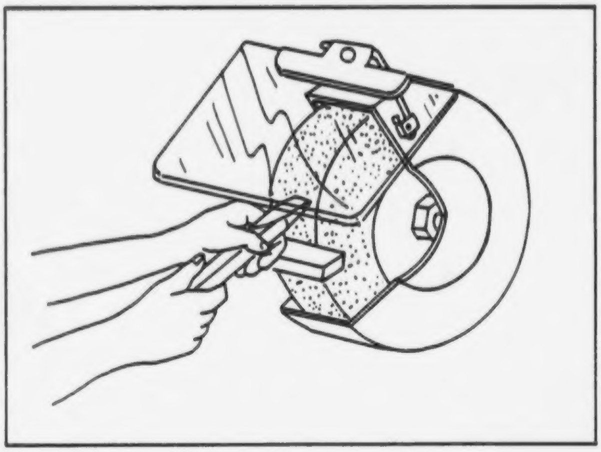
- When passing a tool to a classmate, pass the tool so that he or she can grasp the handle end first.

2. Power tools

Tools powered by electricity, hydraulics or compressed air are called power tools. If they are not handled properly, power tools can cause serious injuries. These rules should be followed when using power tools:

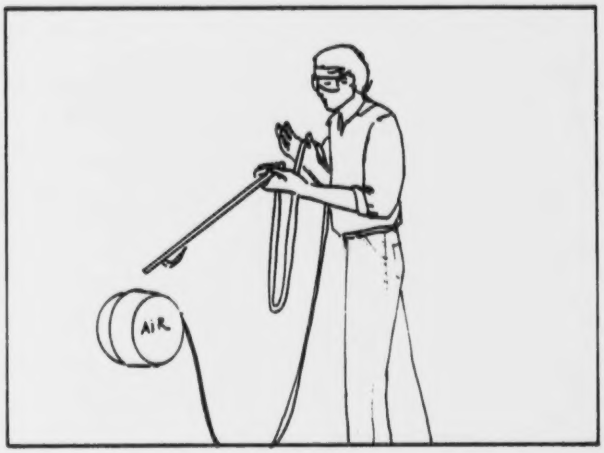
- Always wear safety glasses while using power tools.
- Check all settings on a power tool before turning it on.
- Make sure all classmates are clear before turning a power tool on.
- Keep all of a power tool's safety guards in place while using it.
- Keep all rags and loose clothing away from machines while they are running.





3. Compressed air tools

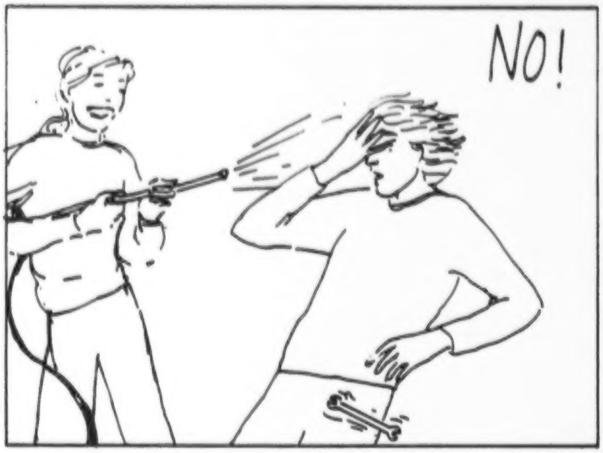
Compressed air has many uses in an automotive shop. It is used to run tools, inflate tires and clean parts. But you must remember that compressed air can be dangerous. The following rules should be observed when using air tools:



- Wear safety glasses while using an air hose.
- Check hoses and hose connections before using compressed air to make sure they are in good repair and properly attached.
- Hold the air hose nozzle when turning air on and off so the hose doesn't "whip" out of control and hurt someone.
- Keep hold of the air hose nozzle while the air machine is running. If you put the hose down, it could rupture or fly out of control.

- Do not use compressed air to dust off hair or clothing or to sweep the floor.

- Never point the air nozzle at anyone or use it for practical jokes.



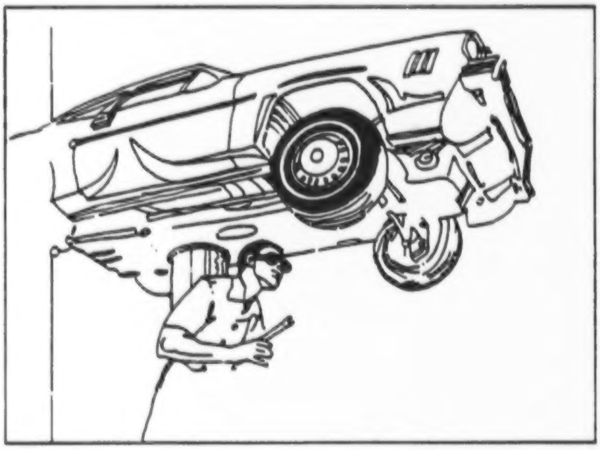
4. Hydraulic jacks and hoists

In order to work under a car, it must be raised on a hoist or lifted with a hydraulic jack. If the car falls off one of these devices, the mechanic working on the car might be seriously injured. These rules should be followed when using hydraulic jacks and hoists:

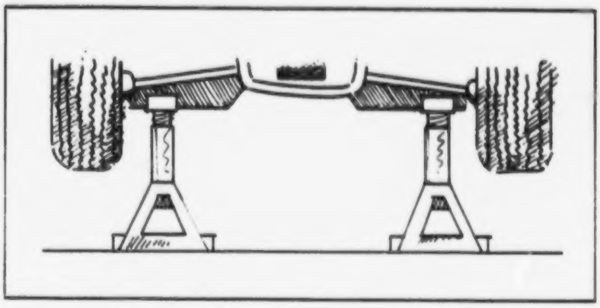
- Wear safety glasses while working under a car.

- Have your teacher check you out on the proper use of these tools before you use them.

- Make sure people and objects are out of the way before raising or lowering an automobile.



- Never get under a car on a jack before supporting it with safety stands that are strong enough to hold the car's weight. Never use bricks or cinder blocks to support a car.

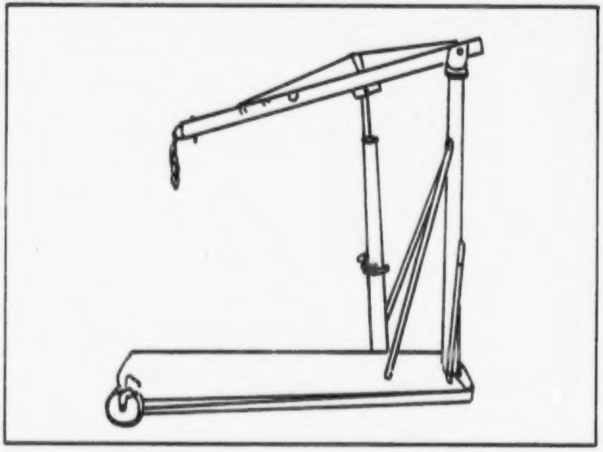


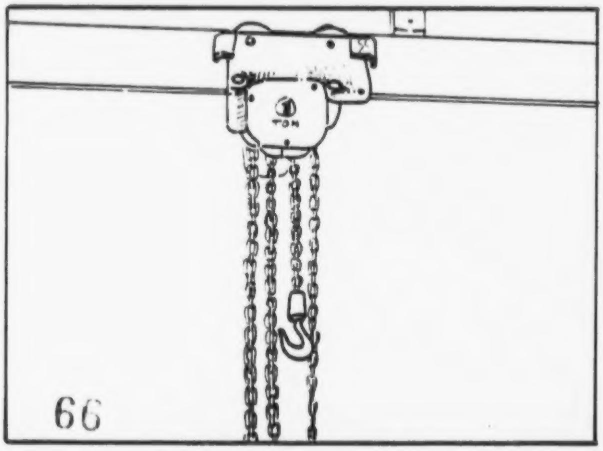
5. **Chain hoists or crane**

Engines and other heavy parts of a car must be lifted out and moved around the shop by using a crane or chain hoist. Because of the weight and size of engines and other components, they must be attached to the crane or hoist properly, and the tools must be in good working condition.

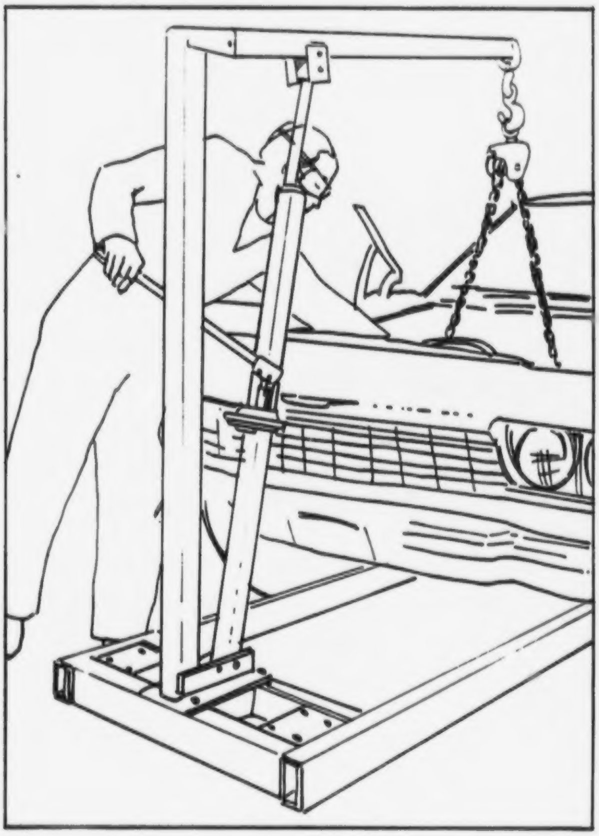
Observe the following rules when using cranes or chain hoists:

- Have your instructor make sure you know how to use the crane or hoist properly.
- Make sure the chain is attached correctly before lifting with the chain hoist.
- Place the crane or chain hoist directly over the object to be lifted.
- Make sure the chain, cable and bolts are in good condition and strong enough to lift the load.





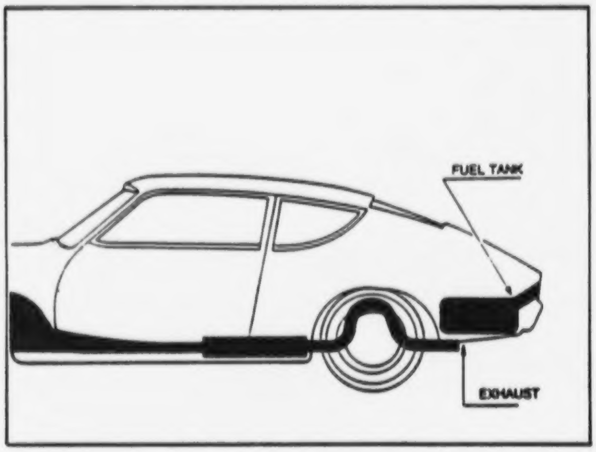
- Check the balance of the object to be lifted.
- Do not lift objects higher than necessary.
- Do not get under objects lifted in the air by a hoist.
- Do not leave an object hanging in the air for a long time.
- When moving a hoist that holds an engine or other heavy object, be sure the load lies close to the floor. If the object rides too highly in the hoist, the hoist or object may tip over.



C. Safety Procedures for Running an Engine in the Shop

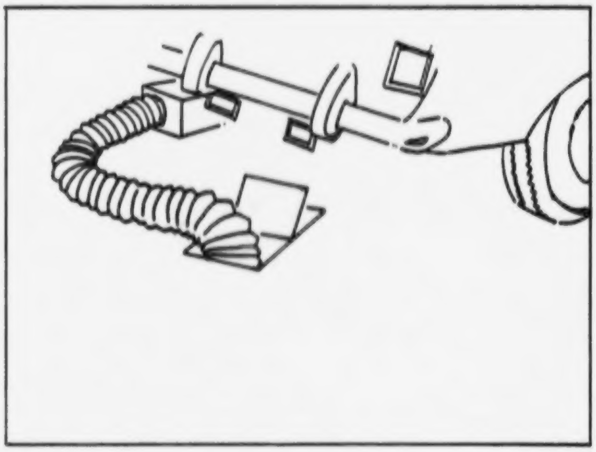
Often in repair procedures, an engine must be run in the shop. Because an engine produces poison chemicals, you must be careful and follow these rules:

1. Wear safety glasses when testing a running engine.



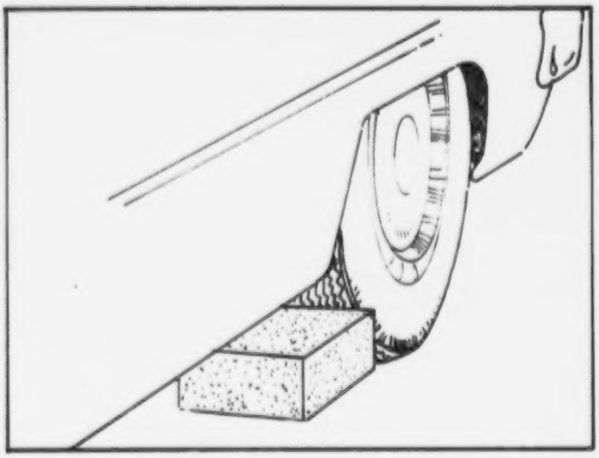
2. Check fuel lines for possible leaks.

3. Vent engine exhaust to the outside of the building; make sure the room is properly ventilated whenever running an engine.



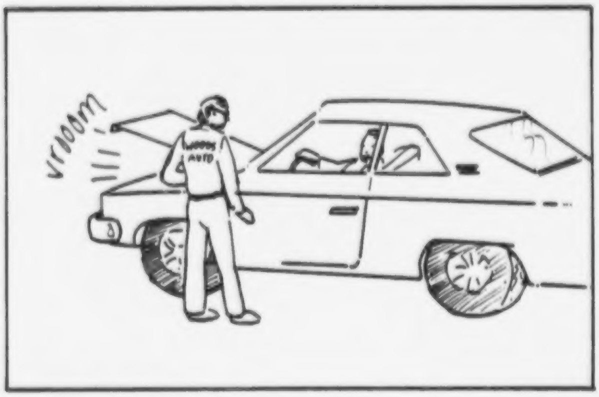
Engine exhaust needs a way to escape. If it cannot leave the room, exhaust slowly fills the shop until no breathable air is left.

4. Keep your head and hands away from spinning fans and belts.



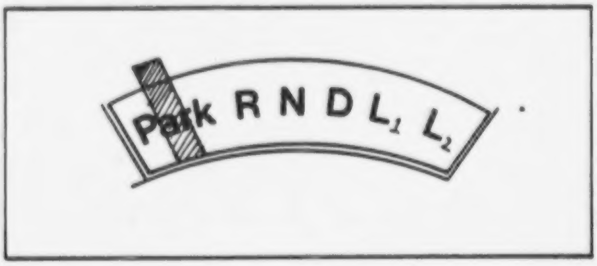
5. If possible, block the car's wheels before starting it.

6. Do not run the engine at high RPM's for long periods of time.



7. Try not to stand in front of or behind a car when its engine is running.

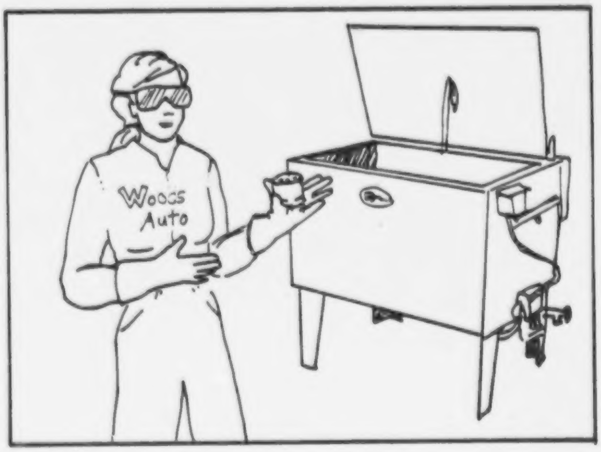
8. Be sure the parking brake is set when a car's engine is running. If the car has an automatic transmission, make sure the selector is in the park position.


Park R N D L1 L2

D. Safety Procedures When Using Cleaning Equipment

In almost every repair operation, you need to clean parts. Most shops use the following ways: steam cleaner, cold tank, hot tank or solvent tank. Bad injuries come when a chemical in one of these cleaners splashes on your body or in your eyes. To avoid bad accidents, observe the following rules:

1. Always wear safety glasses when working with cleaning equipment.

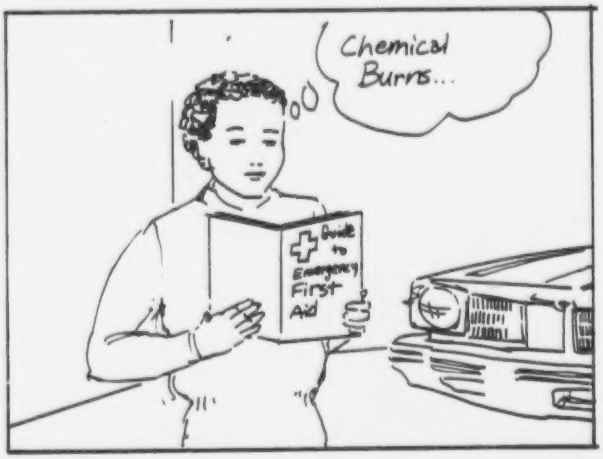


2. Wear rubber gloves and a shop coat or coveralls when working with the hot or cold tank.

3. Have your instructor check your knowledge of proper procedure before using a cleaning tool.

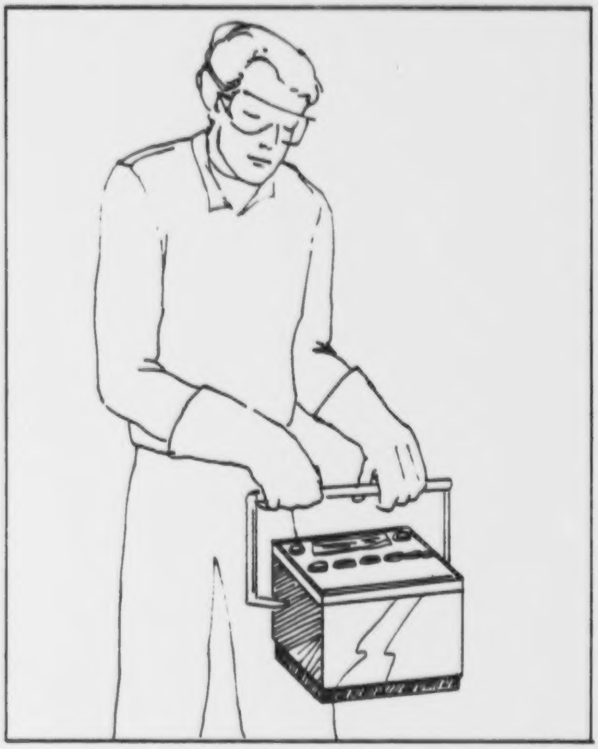
4. Never use gasoline or other flammable liquids to clean parts.

5. Know how to treat a chemical burn in an emergency.


Chemical Burns...
Guide to Emergency First Aid

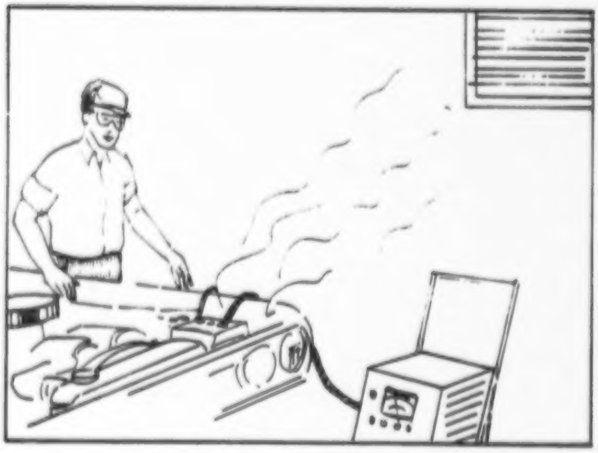
E. Safety Procedures for Storage Batteries

You must be careful working with or around batteries. When charging, the battery gives off an explosive gas. The acid in a battery is also bad for eyes and skin. To avoid accidents, these rules should be followed when working with a storage battery:



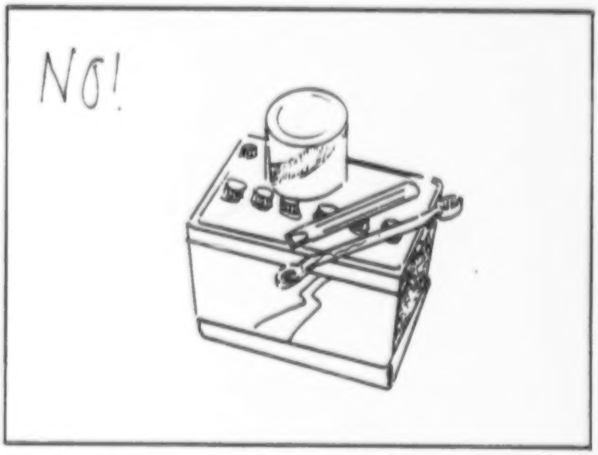
1. Wear safety glasses while working with a battery.
2. Use proper instruments for testing a storage battery.
3. Avoid overfilling unsealed batteries, especially when they are to be charged.
4. Use water and baking soda to clean off the top of the battery.
5. Use a battery lifter to take out and move a battery.
6. Handle battery and battery acid with care. Quickly wash any part of your body or clothing that touches battery acid.

7. Make sure you have good shop ventilation when charging a battery.



8. Keep open flame and sparks away from a battery.

9. Turn off the charger before taking off or attaching the leads from the charger to the battery.



10. Do not store parts or tools on the battery.

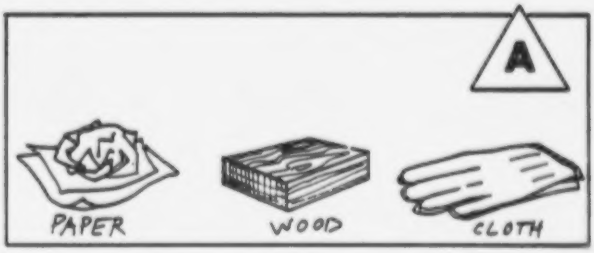
11. Do not short the battery on purpose.

12. If you get battery acid, or any other chemical, in your eyes, don't rub your eyes. Go to the Eye Flush station in your shop and rinse them out. Then get medical help.

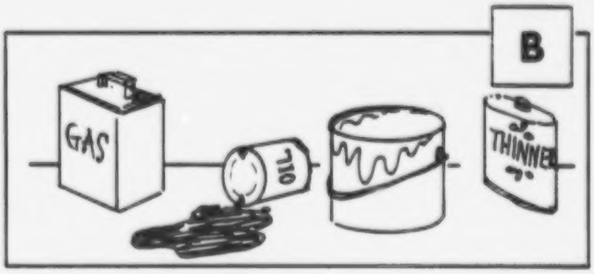
F. Fires and Fire Prevention

Many materials that easily start fires are used in the shop. Because of these materials, every worker in the shop must know how to prevent fires and how to fight a fire in an emergency.

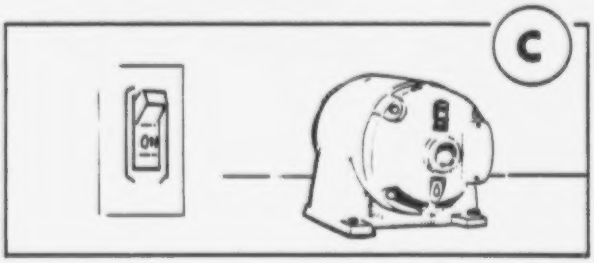
1. There are four main types of fires:



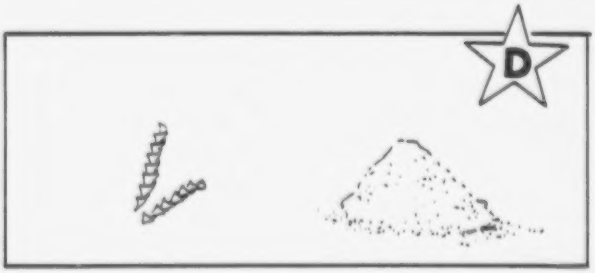
- Class A fires involve solid materials such as paper, wood or cloth.



- Class B fires involve liquids such as gasoline, oil, paints or solvents.



- Class C fires are electrical, involving switches, motors and transformers.

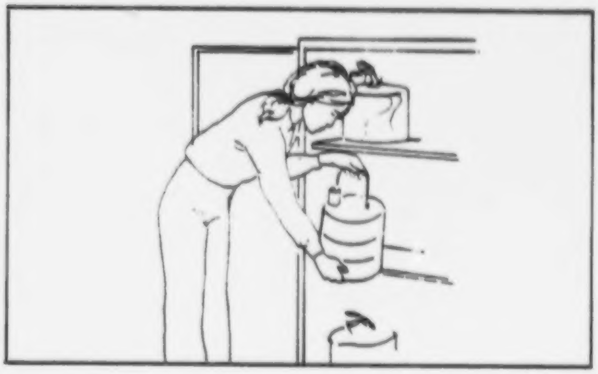


- Class D fires involve metals such as magnesium or powdered steel.

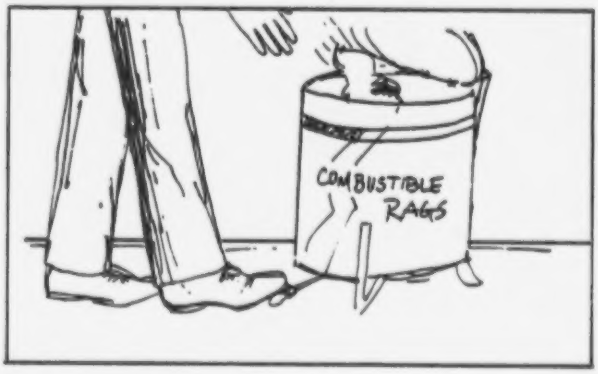
Most shops have fire extinguishers that will put out A, B and C fires, which tend to be most common.

2. Follow these fire safety rules:

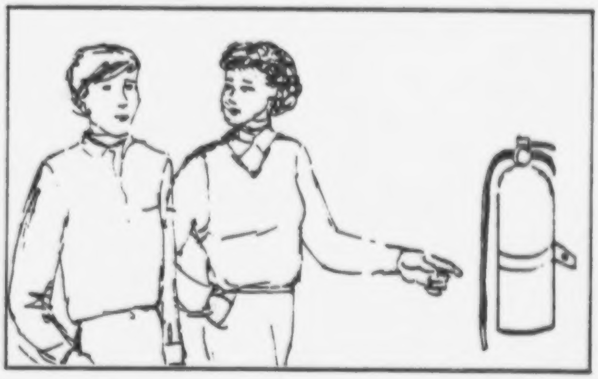
- Store flammable liquids in a fireproof room or cabinet.



- Do not bring too much flammable liquid into the shop. Only bring in liquid that will be used right away.
- Keep all flammable liquids in approved containers.
- Use only approved cleaning solutions and methods.
- Place rags containing oil, gasoline, paint, solvents and other combustible materials in a special metal container.



- Dispose of unwanted fire-causing liquids and materials daily.
- Materials that might burn should be kept away from oil drums, especially from the tops of oil drums.
- Know how to locate and use properly all fire extinguishers in the shop.



- If a fire occurs, inform your teacher immediately.

SKILL SHEET 1

1. When passing a hacksaw to a classmate,
   a. pass it so that he or she can grasp the handle end first.
   b. pass it so that he or she can grasp the blade end first.

2. You (must, must not) wear safety glasses when using hand tools.

3. It (is, is not) O.K. to get under an object hoisted in the air.

4. When a car's engine is running,
   a. make sure the gear selector is in "park," and the parking brake is set.
   b. try not to stand in front of or behind the car.
   c. keep your head and hands away from spinning fans and belts.
   d. all of the above.

5. List the four classes of fires and tell what materials they involve.

	Class	Materials
1.	____________________	________________________
2.	____________________	________________________
3.	____________________	________________________
4.	____________________	________________________

SAFETY INSPECTION

ACTIVITY SHEET 1

1. Put on your safety glasses.

2. Inspect your shop for safety problems. Answer the following questions and give your shop a number grade from 1 to 10 for each of the following items (with ten being excellent and one being poor).

_____ a. How many fire extinguishers does your shop have? Where are they located? ____________________________

____

_____ b. Is everyone wearing safety glasses? ________________

c. Are the hand tools clean and in good condition? Describe their condition. ____________________________

____

_____ d. Are the chain, cable and bolts on your chain hoist or crane in good condition? Describe their condition. ______

____

_____ e. Do you have a fireproof room or cabinet in your shop? Are all flammable liquids stored inside it? Explain. ______

____

____ f. Are all flammable liquids in approved containers? Describe. ____________________

____

____ g. Are rags that have oil, gas or solvents on them stored in a special metal container? Explain. ____________________

____

____ h. Have materials that might burn been placed on top of oil drums? Explain. ____________________

____

____ i. Are there any unsafe areas in your shop? Describe the unsafe areas and explain why they are unsafe. ____________________

____

____ j. Is there more than one emergency exit in case of fire? Where are the exits? ____________________

____

3. Add up the points your shop has gained. ____________________

4. Compare your scores with others in the class. Vote on what a "passing" grade should be. (90 points might be good.)

5. During a class discussion, compare your scores with others in your class. Why were some scores higher or lower than others? Can you correct the problems you discovered?

UNIT REVIEW

1. Use baking soda and water to clean the top of a battery.
   True False

2. A class A fire involves a metal such as magnesium or powdered steel.
   True False

3. The battery charger should always be turned off before unhooking the battery from it.
   True False

4. Battery acid is good for the skin and eyes.
   True False

5. You should never use gasoline to clean parts.
   True False

6. Safety glasses are not needed when working on a running engine.
   True False

7. The parking brake should always be set before starting an engine that needs repair.
   True False

8. The crane or chain hoist must be placed directly over the object to be lifted.
   True False

9. Make sure others are out of the way before starting power equipment.
   True False

10. You can use compressed air to clean a shop floor.
    True False

Student ______________________________ has successfully completed the following tasks.

PERFORMANCE CHECK LIST

TASKS	YES	NO	COMMENTS
1. Put on his/her safety glasses.			
2. Showed how to properly use hand tools.			
3. Showed how to properly use power tools.			
4. Showed how to properly use compressed air tools.			
5. Showed how to properly use hydraulic jacks and hoists.			
6. Showed how to properly use chain hoists and cranes. Using these tools, properly attached and balanced an automobile component.			
7. Showed how to properly vent an automobile in the shop area.			
8. Showed how to properly use different types of cleaning equipment such as steam cleaner and/or hot, cold and solvent tanks.			
9. Showed how to properly charge, handle and store a storage battery.			

TASKS	YES	NO	COMMENTS
10. Listed the four types of fires and the combustible materials involved in each.			
11. Explained how to properly store and dispose of combustible materials.			
12. Showed how to properly use fire extinguishers.			
13. Showed how to properly use any other important specialized tool in the shop, at the direction of the instructor.			

Student should move on ☐

Student should repeat this unit ☐

Student's Signature/Date

Instructor's Signature/Date

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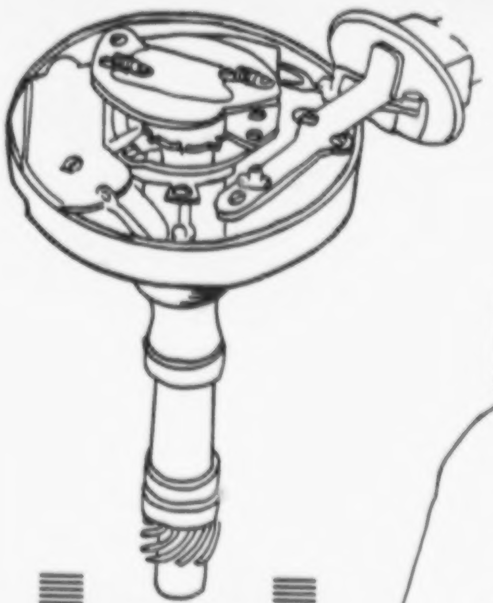
Auto Mechanics

Supplementary Units



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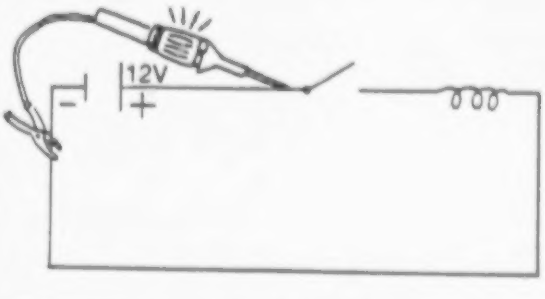
COLUMBIA, MO 65211



Unit 3

Preventive Maintenance Inspection

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PREVENTIVE MAINTENANCE INSPECTION

INTRODUCTION

In this unit, you will learn how to do "scheduled maintenance" on a car. Because you can catch problems before they become serious, these routine checkups on your car's systems are often the most important you perform.

UNIT OBJECTIVE

After studying this unit, you will be able to do the scheduled preventive maintenance on an automobile.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to specifically:

1. Inspect the exhaust system for leaks or rust holes in the pipe and muffler.
2. Recognize signs of wear or problems in the steering, brake and exhaust systems.
3. Check and correct fluid levels.
4. Change the oil and oil filter.
5. Inspect and grease steering system.
6. Recognize safe, operable fan belt.
7. Install wheels and torque them to manufacturer's specifications.

Check the Statement that Fits You Best .

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Antifreeze** - a solution that raises the boiling point and lowers the freezing point of the water in the cooling system; also called "coolant."

2. **Axle boots** - a synthetic rubber bag or cover that encloses and protects the axle joints, keeping dirt out and grease in.

3. **Ball joint** - a movable joint found in the steering system of a car that fastens each front wheel spindle to the suspension system and lets the front wheels move back and forth.

4. **Dipstick** - a metal stick that is inserted and taken out of a reservoir to check the level of fluid inside.

5. **Disc brake pad** - a flat piece of metal, positioned next to the rotor, with a heat resistant lining that slows or stops the car when the pad is forced against the brake rotor.

6. **Drag link** - a steel rod connecting the pitman arm to one of the steering knuckles or to a center idler arm.

7. **Drum brake shoe** - a curved piece of metal in a drum break system that has a heat resistant lining which slows or stops the car when the shoe is forced against the brake drums.

8. **Engine oil** - a thick liquid that lubricates and cools the moving parts of an engine and reduces rust and corrosion.

9. **Fan belt** - one of the drive belts in the engine, a reinforced rubber belt that drives the fan and the alternator.

10. **Glazing** - a very smooth, glassy finish.

11. **Grease gun** - a device that can be filled with grease and used to lubricate a car.

12. **Hoist** - a device used to lift a car so the car's underside can be serviced. It can also be called a "lift" or "hydraulic."

13. **Hose** - a flexible tube that carries flowing fluids.

14. **Hydrometer (Cooling System)** - the device used to determine the percentage of coolant in the cooling system.

15. **Lug wrench** - a wrench used during tire changes to remove the lug nuts that hold the wheel onto the car.

16. **Muffler** - a device that quiets the noise made by exhaust gases before they go through the tail pipe and into the air.

17. **Pitman arm** - a short lever arm that transmits steering force from the steering gear cross shaft to the steering linkage system.

18. **Power steering fluid** - a special hydraulic oil used in power steering systems.

19. **Rack and pinion** - a steering system used on smaller cars because of its lightness and simplicity.

20. **Radiator** - the device that cools the liquid in the cooling system by sending the liquid through a series of tubes exposed to air.

21. **Safety stand** - a safety device that keeps the car from falling if the jack is removed or breaks.

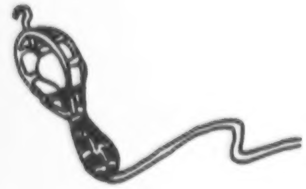
22. **Tie rod ends** - the ball joint couplers on the ends of the steering linkage.

23. **Torque wrench** - a special wrench that can measure the exact amount of torque (twisting power) being applied to tighten a bolt.

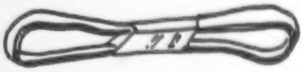
25. **Transmission fluid** - a thin oil used in automatic transmission systems.

Equipment:

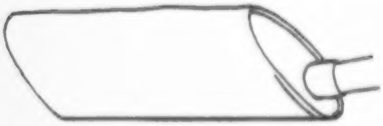
Drop light



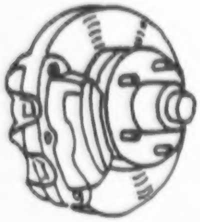
Fan Belt



Muffler

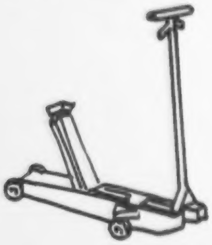


Brakes



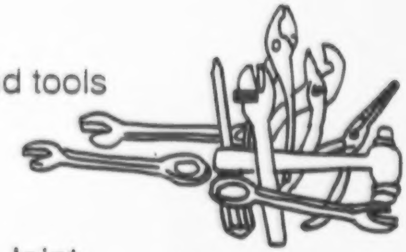
Seat cover

Jack

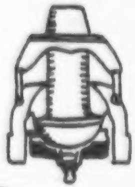


Tires

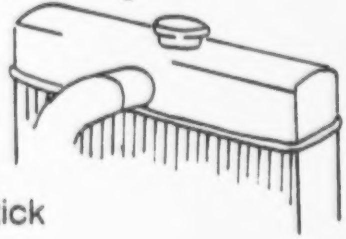
Hand tools



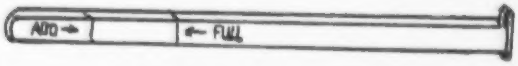
Ball Joint



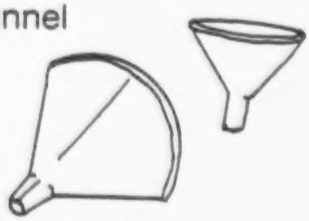
Radiator



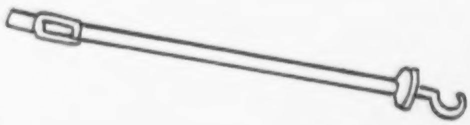
Oil dip stick



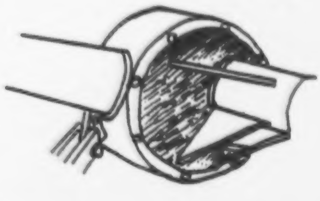
Funnel



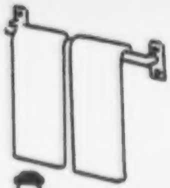
Transmission dip stick



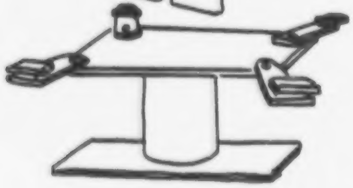
Rear axle



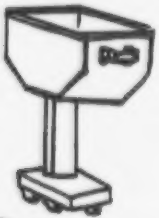
Shop Towels



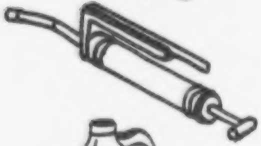
Hoist



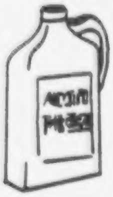
Drain pan



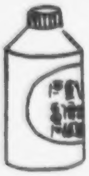
Grease gun



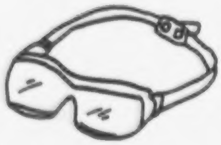
Antifreeze



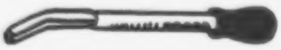
Power steering fluid



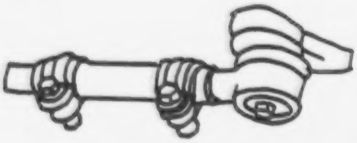
Safety glasses



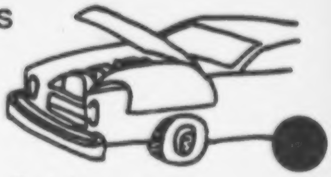
Cooling system hydrometer



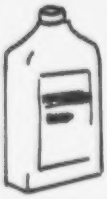
Tie rod ends



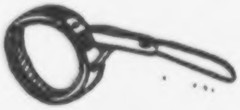
Fender covers



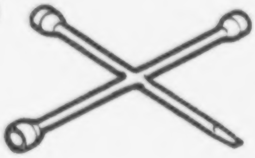
Transmission fluid



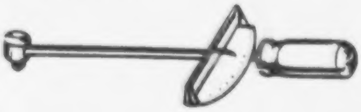
Oil filter wrench



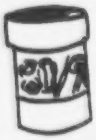
Lug wrench



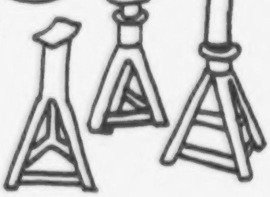
Torque wrench



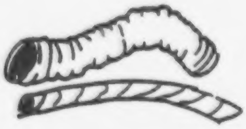
Rear axle lubricant or 80-90



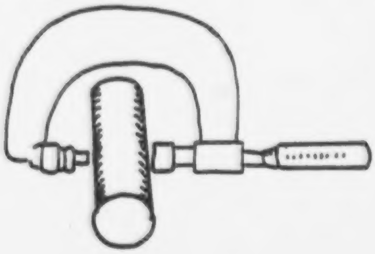
Safety stands



Hoses



Micrometers



B. Preventive Maintenance Inspection

ALWAYS WEAR SAFETY GLASSES

Vehicle inspection is a needed and important process. It must be done on a regular basis. A car that goes unattended is much more likely to break down and leave the driver stranded.

Even worse, a worn-out part may fail while the car is moving. If so, an accident may occur.

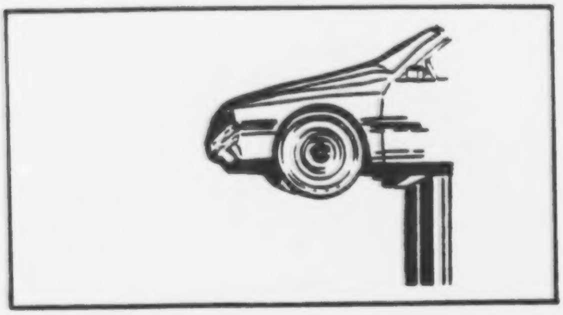
You will need the following equipment:

Safety glasses
Hoist or Jack
Safety stands
Fender cover
Shop towels
Hand tools
Drop light
Seat cover

Procedure

1. Pull the car onto a hoist and raise it (or pull the car onto a jack and lift it). Secure the car with safety stands.

Always follow the car maker's instructions when lifting a car.



2. Carefully study the underside of the car. If you can catch a problem early, it will often be less expensive to fix and will make the car much safer to ride in.

3. Inspect the steering linkage for wear and looseness. There should be smooth, even movement when the steering is turned.

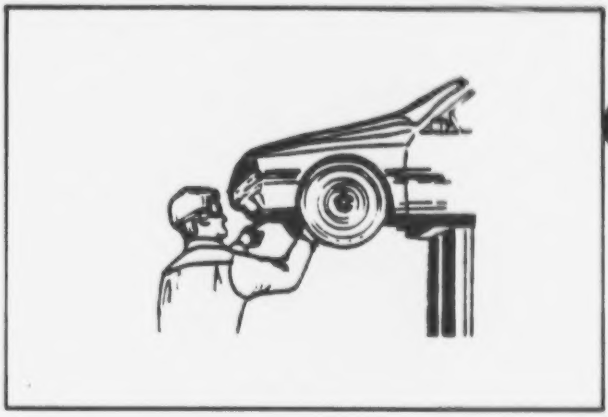
   Looseness may mean the parts are abnormally worn. Check for looseness by gripping the steering linkage and seeing if it will move. (Refer to the car's service manual for the acceptable amount of play in each joint.)

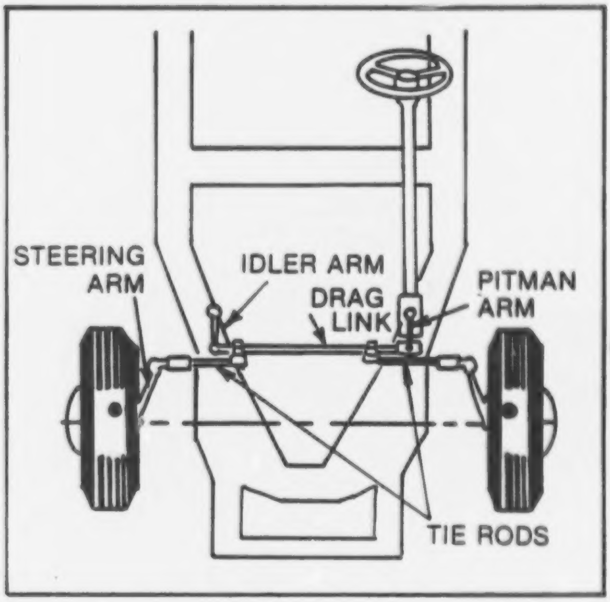
   On a conventional steering system, you must look at the tie rod ends, drag link, ball joints, idler arm and pitman arm.

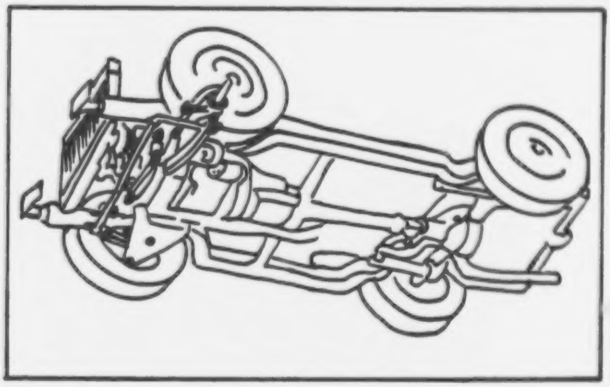
   (A special procedure is used when checking ball joints. The procedure is not covered in this unit. See your instructor for information.)

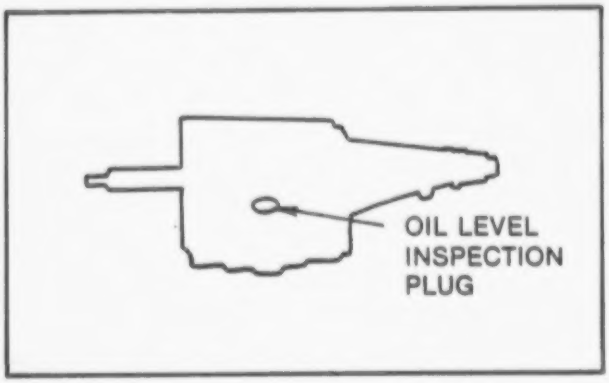
   On rack and pinion systems, check tie rod ends, rubber boots and mounting bolts.

4. Check the transmission or trans axle assembly for leaks and good mounts.

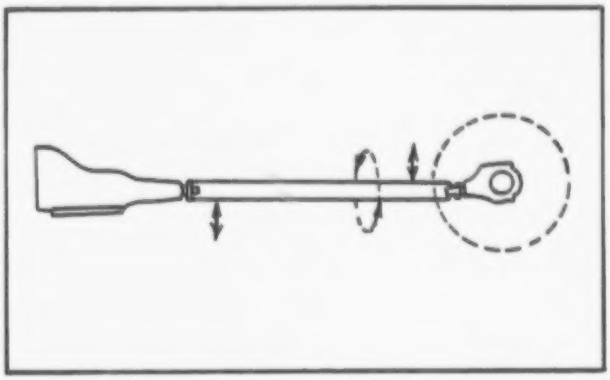






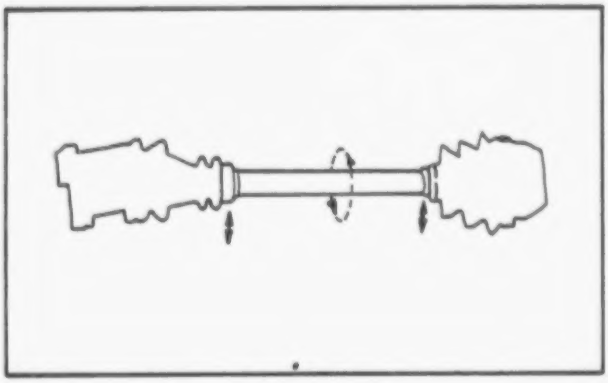


5. For manual transmissions and trans axles, remove the upper plug in the transmission housing. The fluid level should be up to the bottom thread of the hole; a slight amount of fluid may run out.



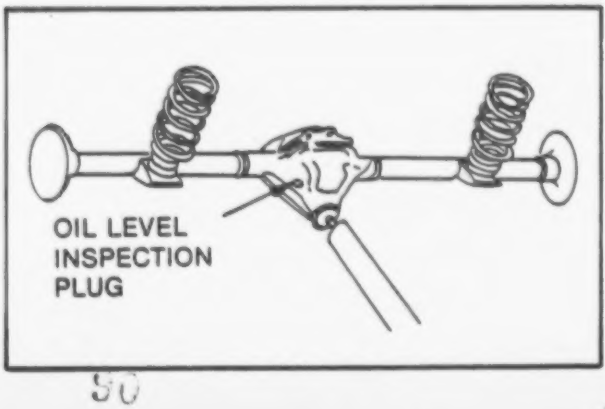
6. Check the drive shaft for looseness.

   On rear wheel drive cars, make sure the drive shaft rotates smoothly and that the shaft's universal joints are not too loose.



   On front wheel drive cars, make sure both axle shafts rotate smoothly. Check them for looseness. And make sure the rubber boots on the front axle shaft have no holes in them.

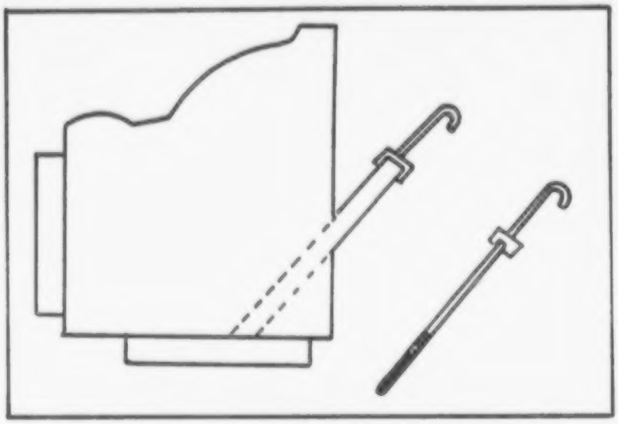
7. Check the differential fluid level.



- On rear wheel drive cars, you must remove a plug in the differential housing to check the fluid level.

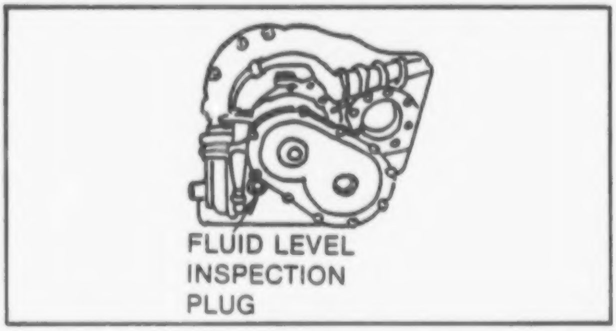
  The fluid level should be at or equal to the lower portion of the inspection plug hole; a slight amount of fluid may run out.

- On most front wheel drive cars with automatic transaxles, you check the differential fluid level with the transmission's dipstick when you check the transmission.



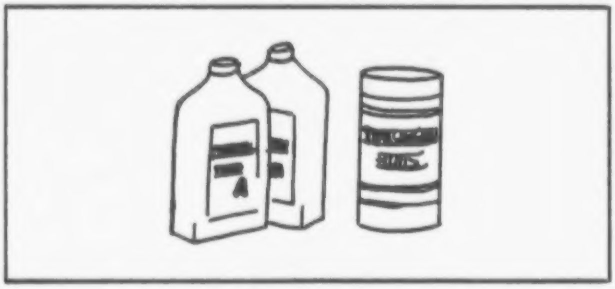
- On most front wheel drive cars with manual transaxles, you check the differential and manual transaxle by removing an inspection plug.

  The fluid level should be above or at the lower portion of the inspection plug hole; a slight amount of fluid may run out.

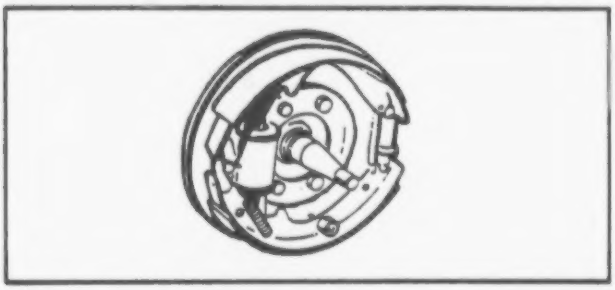


  NOTE: Some manual transaxles have two inspection plugs.

  NOTE: Make sure you add the correct fluid if some is needed. Some manual transaxles use automatic transmission fluid.

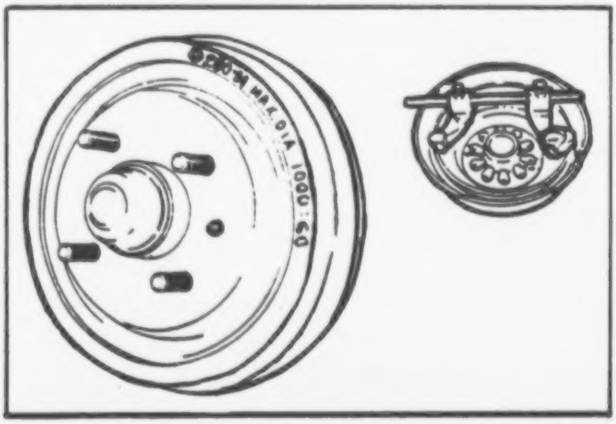


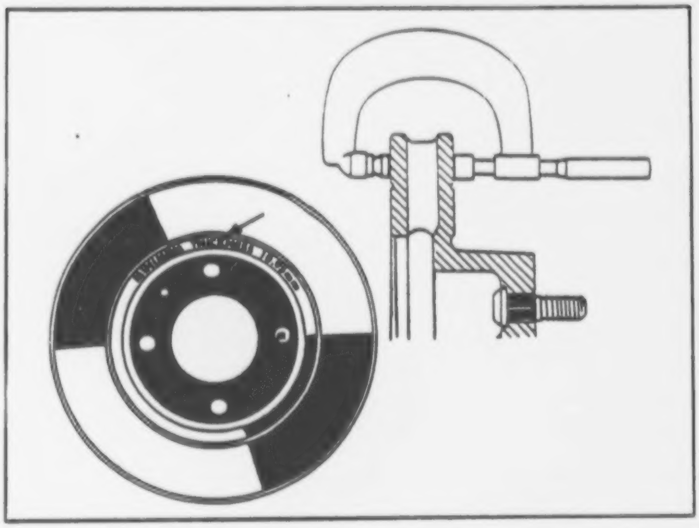
8. Remove one front wheel and one rear wheel. Inspect the brake lining for abnormal wear.



   NOTE: Brake asbestos may be dangerous. See your instructor for advice.

   (See the car's service manual for specifications on acceptable brake lining wear and drum or rotor size.)

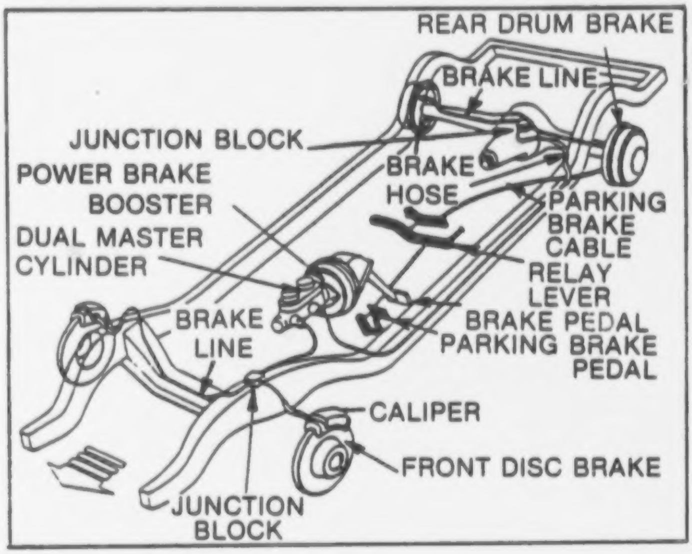




If the break shoe lining is rough and uneven, the brakes may need repair. Normal wear on the brake lining is smooth and even.

(Brake service is not covered in this unit. See your instructor for information.)

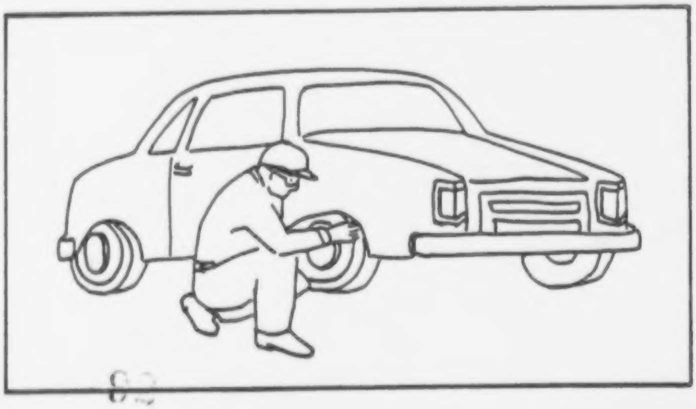
9. Check at all four wheels for break fluid loss at the lines and backing plates.


REAR DRUM BRAKE
BRAKE LINE
JUNCTION BLOCK
POWER BRAKE BOOSTER
DUAL MASTER CYLINDER
BRAKE HOSE
PARKING BRAKE CABLE
RELAY LEVER
BRAKE PEDAL
PARKING BRAKE PEDAL
BRAKE LINE
CALIPER
FRONT DISC BRAKE
JUNCTION BLOCK

10. Put the front and rear tires back on. Torque them to manufacturer's specifications using the star pattern.

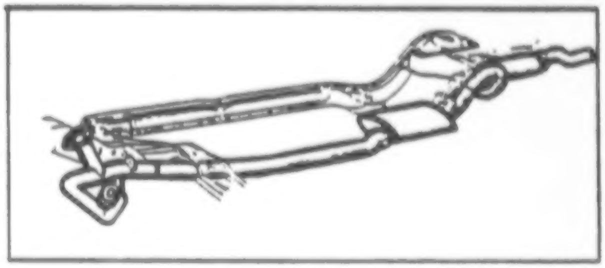
11. Check the tires for air pressure and abnormal wear. Look for uneven wear, cupping of the tread or cracks in the sidewall or tread.

Careful study of tire wear can show which driving angles need to be fixed. If wear is uneven, the suspension system may need to be realigned. A realignment of the suspension system is known as "wheel alignment."



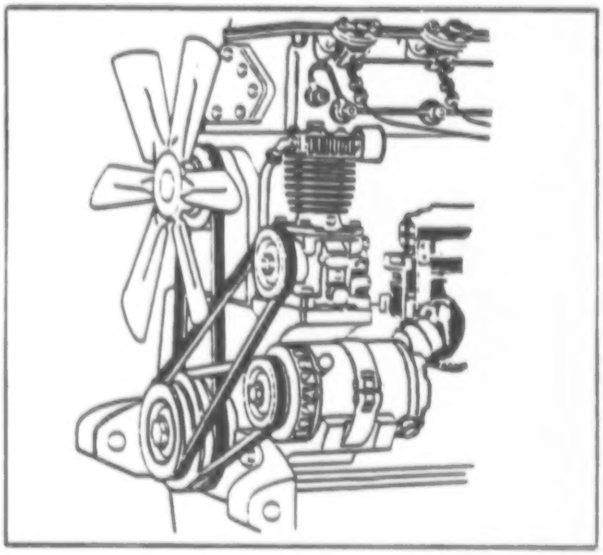
12. Check the exhaust system for leaks and rust holes in the pipes and muffler.

    Make sure all hangers and clamps are in place and in good shape.



13. Lower the car and inspect under the car's hood.

14. Check the fan belts for:
    - cracks
    - glazing
    - tightness.

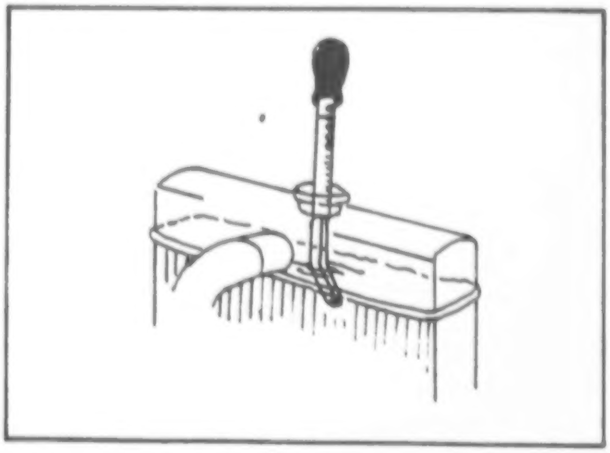


15. Check all hoses for:
    - cracks
    - bulges
    - bad clamps

16. Check to make sure the radiator is full. The mixture of water and antifreeze in the radiator should come to within two inches from the top of the radiator.

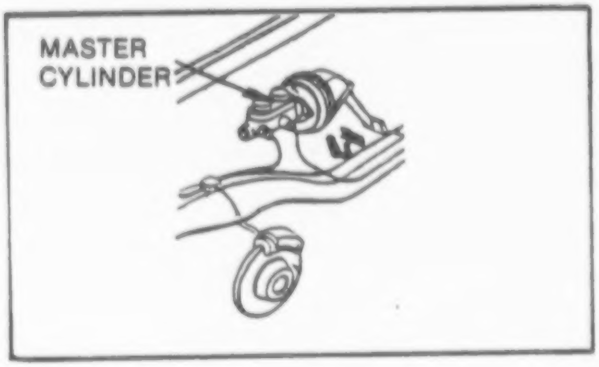
    (CAUTION: Do not remove the radiator cap unless the car's engine is cool. Otherwise, the radiator's contents will explode through the cap opening and burn you.)

17. Using a cooling system hydrometer, determine boiling and freezing points in the radiator. A hydrometer usually looks like a glass tube with a float in it.



Insert the hydrometer into the radiator and squeeze in some radiator water. Use the hydrometer's scale to measure the boiling and freezing points.

18. **Check the master cylinder for external leaks.**



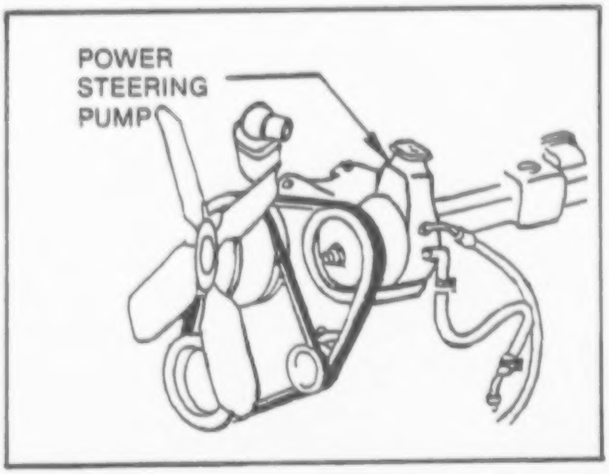
19. Check the master cylinder fluid level.

    Use brake fluid with a DOT 3 rating and fill to 1/4" of the top.

20. **Some manual transmissions or transaxles have a hydraulic clutch. The clutch system has a master cylinder similar to the master cylinder on the brake system. It is checked the same way as the master cylinder on the brake system.**

21. Check the fluid level in the power steering pump.

    (Most cars must have the engine running to check the power steering fluid level.)

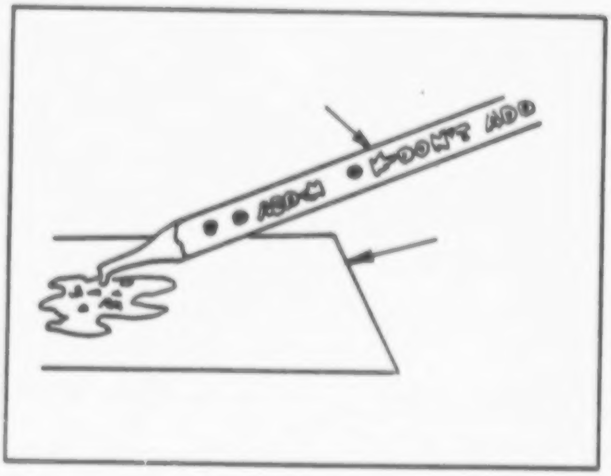


Older cars may use transmission fluid in place of power steering fluid, but only use power steering fluid on newer cars.

22. Start the car and let it warm up.

23. After the car has reached operating temperature, pull the automatic transmission dipstick out and check the fluid level.

    Check to make sure:
    a. the fluid is at the proper level
    b. the fluid does not look burnt
    c. the fluid does not smell burnt



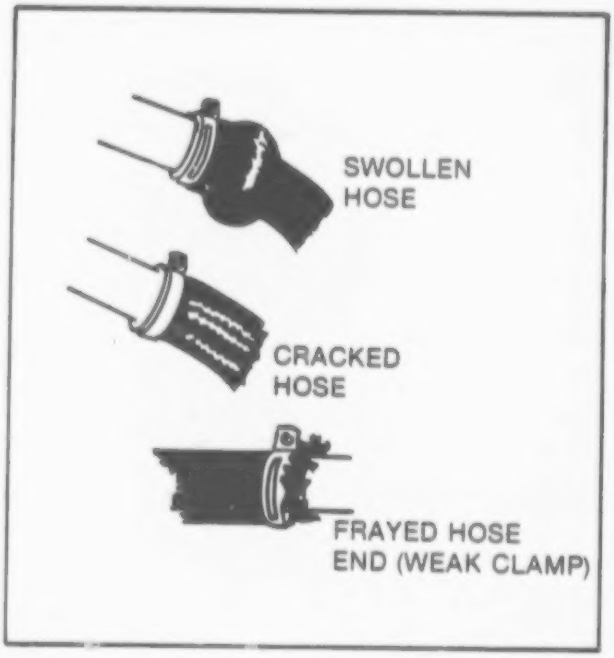
24. Shut off the car.

25. Check for cracked or broken vacuum lines and hoses.

26. Examine the wiring for bare or frayed spots and corroded terminals.

27. Take the car off the hydraulic lift.

28. Put away the tools and equipment and clean the work area.



DO SKILL SHEET 1

DO ACTIVITY SHEET 1

SKILL SHEET 1

Directions: Complete the following statement with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

1. A tie rod that is able to move up and down 3/8 of an inch is (O.K., not O.K.).
2. Manual transissions and transaxles (are, are not) checked with a dipstick located under the hood.
3. The asbestos dust that comes off the brakes (is, is not) harmful to your health.
4. Never take the radiator cap off the radiator when the coolant is (cold, hot).
5. All power steering systems (do, do not) use automatic transmission in them.

PREVENTIVE MAINTENANCE INSPECTION

ACTIVITY SHEET 1

1. See your instructor to get a car that needs a preventive maintenance inspection.

2. Review the procedure outlined in this unit and review the appropriate service manual for the car.

3. Get the proper tools and equipment.

4. Complete the inspection procedure.

ALWAYS WEAR SAFETY GLASSES WHEN WORKING ON CARS.

5. Record your results.
   Steering linkage

   Transmission

   Differential fluid

   Drive shaft

   Brakes

Tire wear____

Exhaust system____________________________________

Fan belt____

Hoses____

Antifreeze_______________________________________

Brake fluid______________________________________

Clutch fluid______________________________________

Vacuum lines_____________________________________

Wiring____

6. Put away your tools and equipment and clean up the work area.

C. Procedure for changing the oil and filter and for greasing the steering system.

ALWAYS WEAR SAFETY GLASSES.

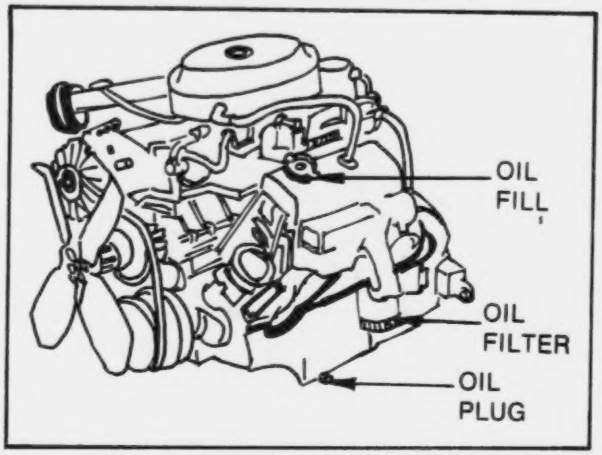
A car that is serviced regularly will last much longer than a car not serviced regularly. Often manufacturers recommend service intervals for their cars. In other words, the car maker tells how often a part should be serviced. It is a good idea to follow these recommended intervals.

You will need the following equipment:

Safety glasses
Hoist or Jack
Safety stands
Fender cover
Shop towels
Hand tools
Drop light

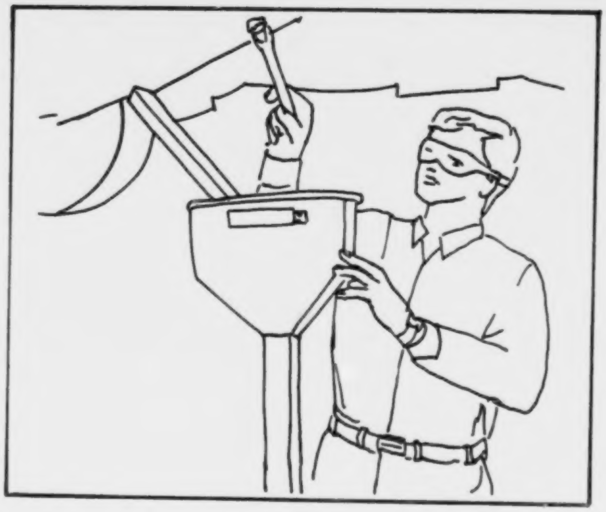
Seat cover
Funnel
Drain pan
Oil filter wrench
Oil
Oil filter
Grease gun

1. Pull the car onto the hoist and raise it (or lift the car with a jack) and secure it with safety stands.
2. Loosen the drain plug in the engine oil pan.
3. Position the oil catch pan under the plug.



4. Carefully remove the plug and let all the oil drain out.

   (Be careful not to lose the washer or the oil drain plug.)

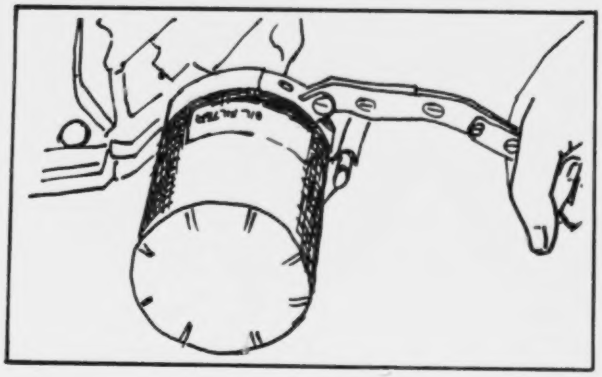


5. Install the oil drain plug and washer. Tighten it to specification, but be careful not to make the plug too tight.

6. Position the oil catch pan under the oil filter.

7. Remove the oil filter using an oil filter wrench.

   (Make sure the old "o"-ring gasket is not on the sealing surface, where the new filter goes.)



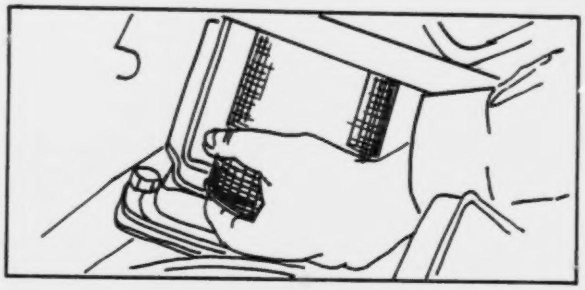
8. Compare the old and new filter to make sure the threads, "o"-ring and size are correct.

9. Wipe off the filter's sealing surface on the engine block.

10. Lube the new oil filter "o"-ring with some clean oil.

11. Install the new oil filter. (Follow the tightening instructions that come with the new filter.)

    Be careful not to dent or make the canister too tight.

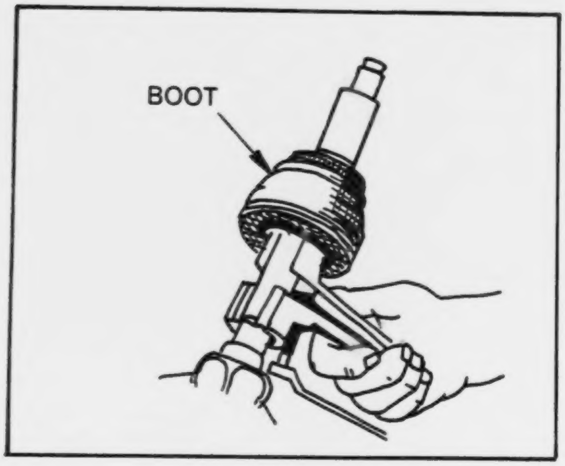


12. If the steering system and suspension system are in good condition, lube the components in both systems that have grease fittings installed in them.

    The boots should not be pushed out of their seats.

    Be careful not to fill the boots with too much grease.

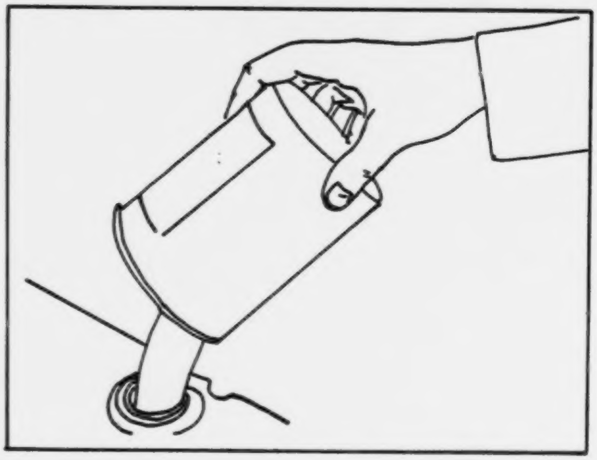
    (Do not lube worn components. They should be replaced.)



13. Lower the car.

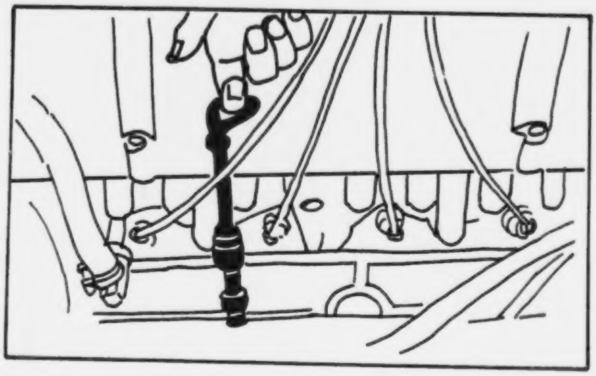
14. As soon as the car is down, fill the engine with the correct amount of oil.

    (Fill the engine as soon as possible so someone will not come over and start the engine while it has no oil.)



15. Start the engine and check under the car for oil leaks.

16. Shut the car off and check the engine oil dipstick to make sure the engine is properly filled.



17. Put away your tools and equipment and clean up the work area.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

SKILL SHEET 2

Directions: Complete the following statements (or answer the following questions) with the word or words that make the statement correct. If you are unsure of an answer, look back at the text for help.

1. List three items that must be the same in both the old and new filter.

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. During installation, it (is, is not) possible to put on an oil filter too tightly.

3. Care should be taken to (slightly, never) overfill the boots on the tie rod ends and ball joints.

4. All engines (use, do not use) five quarts of oil when the filter and oil is changed.

5. Fill the engine with new oil (as soon as possible in, at the end of) the servicing process.

PREVENTIVE MAINTENANCE INSPECTION

ACTIVITY SHEET 2

1. See your instructor to get a car that needs an oil change and lube job.
2. Review the procedure outlined in this unit and in the appropriate service manual for the car.
3. Get the tools and equipment you need.
4. Complete the service procedure.

WEAR SAFETY GLASSES

5. Be sure to start the car to check for leaks when you are finished with the procedure.
6. Put away your tools and equipment and clean up the work area.

PREVENTIVE MAINTENANCE INSPECTION

UNIT REVIEW

1. What tool is used to check the freezing and boiling points in the cooling system?

   A. Hydrometer
   B. Dip stick
   C. Torque wrench

2. What tool is used to install wheels to manufacturer's specifications?

   A. Lug wrench
   B. Torque wrench
   C. Air wrench

3. The wheel bolts should be tightened in a star pattern.
   TRUE FALSE

4. When greasing steering linkage, it is okay to overfill the boots.
   TRUE FALSE

5. When checking fan belts, you should look for cracks, glazing and tightness.
   TRUE FALSE

PREVENTIVE MAINTENANCE INSPECTION
PERFORMANCE CHECKLIST

Student ____________________ successfully performed the following tasks:

	Yes	No	Comments
1. Put on his\her safety glasses			
2. Properly put car on lift or hoist			
3. Properly put car on jack stands			
4. Checked steering system			
5. Checked transmission or transaxle fluid level			
6. Checked drive shaft or front axle shafts			
7. Checked rear axle fluid level			
8. Checked brake system (including fluid level)			
9. Removed front wheels and checked brakes			
10. Installed wheels and torqued them to manufacturer's specifications			
11. Changed oil and oil filter			
12. Checked exhaust system			
13. Checked fan belts			
14. Checked radiator antifreeze level			
15. Checked power steering fluid level			
16. Started car and did a final check of oil and transmission fluid levels			
17. Cleaned work area and put away tools			

Should move on ☐

Should repeat this unit ☐

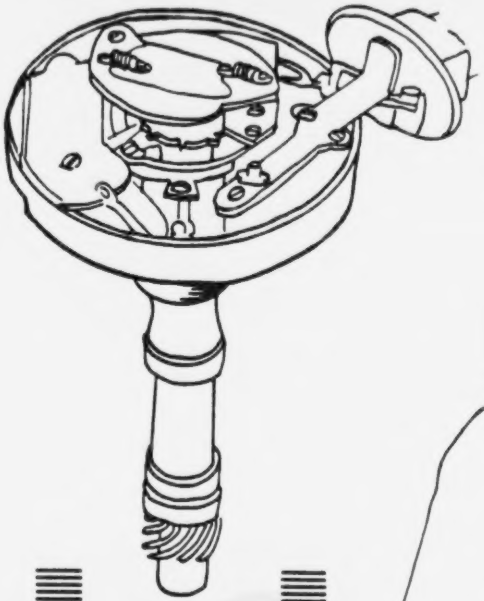
______________________________ ______________________________

Student Signature/Date Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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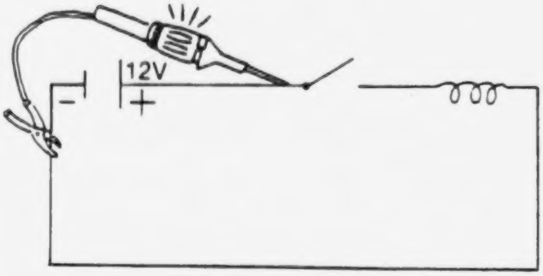

Unit 4

Checking Tire and Wheel Runout and Tire Balancing

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CHECKING TIRE AND WHEEL RUNOUT AND TIRE BALANCING

INTRODUCTION

Proper tire balance is important for the whole car and crucial for the wheel assembly. The tolerance for imbalance in the wheel assembly is so critical that half an ounce of pressure can exert enough influence to imbalance the entire wheel assembly.

If imbalance in the wheel assembly continues for a long period of time, the car becomes less driveable and the life of tires is shortened. This unit will teach you how to correct such tire and wheel problems.

UNIT OBJECTIVES

After completing this unit, you will be able to identify and correct tire and wheel problems.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to specifically:

1. Balance tires statically and dynamically.
2. Measure and correct radial and lateral runout.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Balance** - the situation that occurs when all parts carry equal weight or force; even, steady.

2. **Centrifugal force** - the force that tends to push an object outward from a center of rotation.

3. **Dynamic Balance** - the situation that occurs when the center line of weight mass is in the same plane as the center line of a revolving object.

4. **Imbalance** - the situation that occurs when parts carry unequal weight or force; uneven, unsteady.

5. **Kinetic** - having to do with the motion of an object and its related energy or forces.

6. **Shimmy** - the shaking of front wheels from side to side.

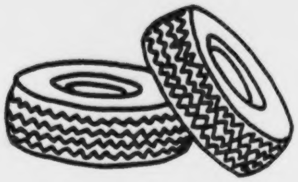
7. **Static balance** - the situation that occurs when weight is evenly distributed around the axle of rotation.

8. **Wheel balancer** - a machine used to check the tire and wheel assembly for static and dynamic balance.

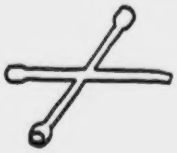
9. **Wheel tramp** - the "hopping" motion caused by static imbalance in the tire assembly.

Equipment

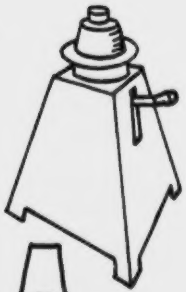
Tires



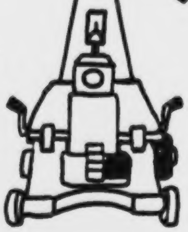
Lug wrench



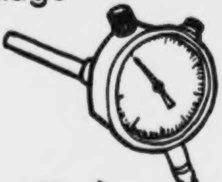
Bubble balancer



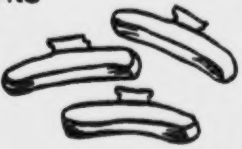
On-car spin balancer



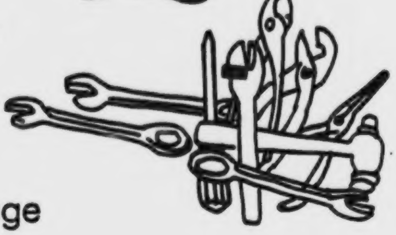
Wheel run out gauge



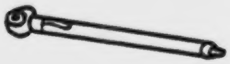
Wheel weights



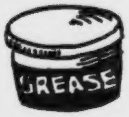
Hand tools



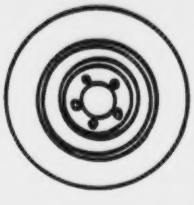
Tire air gauge



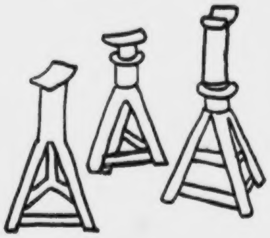
Wheel bearing grease



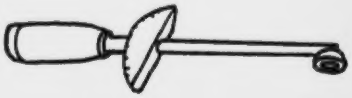
Wheel(Rim)



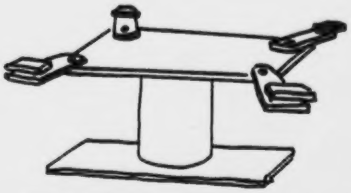
Safety stands



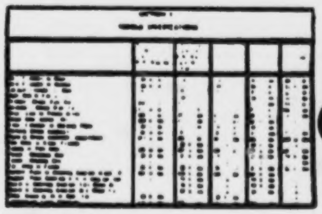
Torque wrench



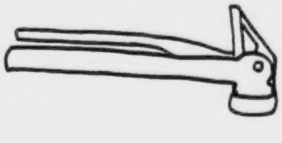
Jack or hoist



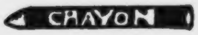
Specifications



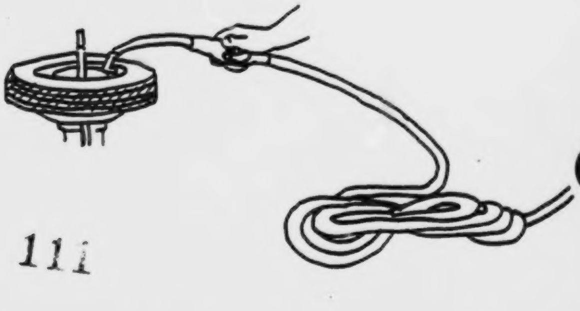
Wheel weight hammer



Tire marker



Air hose with tire inflation tool
(tool is on the end of the hose)



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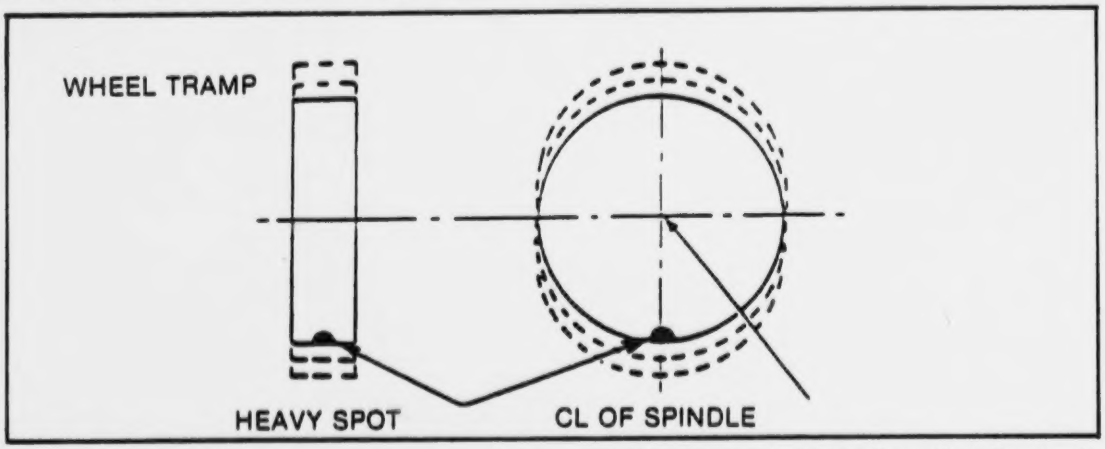
B. Wheel Imbalance Concepts

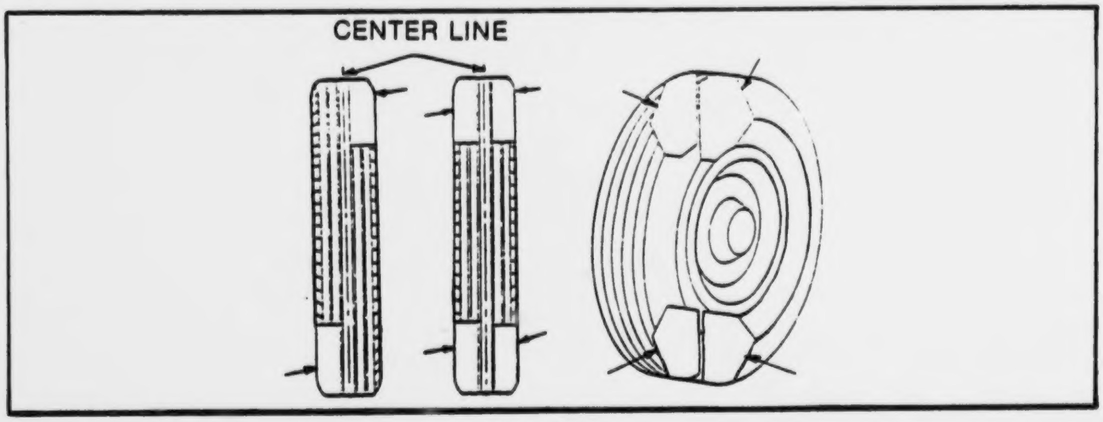
Wheel imbalance generally falls into one of two categories:
static imbalance or dynamic imbalance.

1. **Static imbalance** - occurs when the weight of the tire and wheel assembly is not distributed equally around the spindle. Static imbalance causes the tire assembly to "tramp" or "hop" as the car moves.



2. **Dynamic imbalance** - occurs when weight is not equally distributed around either the axis or the center line of the tire. In order for dynamic balance to occur, the wheel's weight must be balanced both around the axis and on both sides of the center line. If the tire and wheel are in a state of dynamic imbalance, the assembly will tend to wobble.

NOTE: A tire can be in static balance and still not be in dynamic balance.



C. Correcting Tire Imbalance

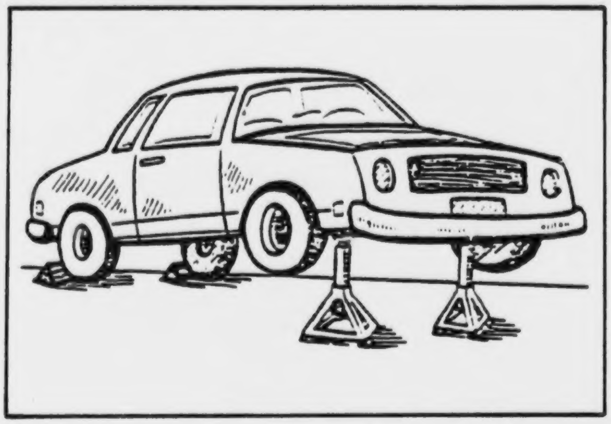
There are several methods to balance a tire. When used properly, you can do a good job of balancing the tire with any of them.

Before you begin, you need to find out if the balancer in your shop is set up to balance a tire on or off of a car. Also, never try to balance a worn-out tire.

1. **Put on your safety glasses.**

2. You may need the following tools:

    Electronic wheel balancer
    Bubble balancer
    Lug wrench
    Floor jack
    On-car spin balancer
    Dial indicator
    Torque wrench
    Jack stands



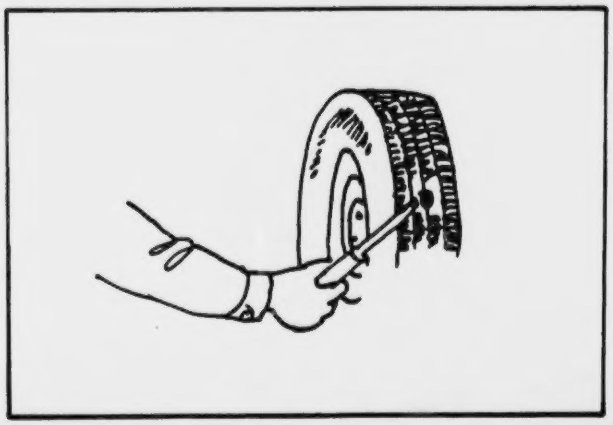
3. Check with your instructor to get a tire that needs to be balanced.

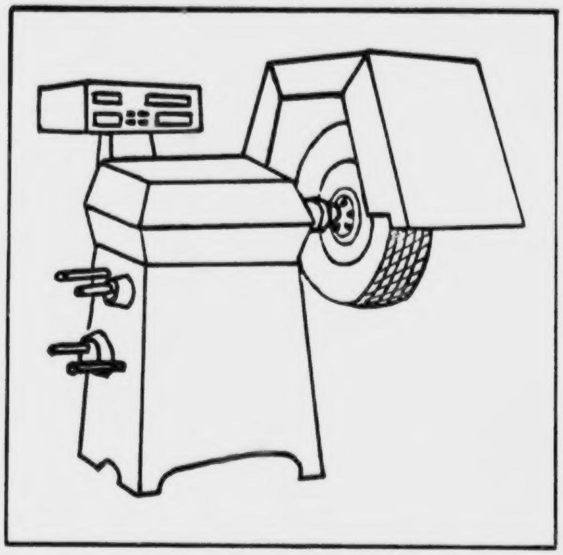
4. Using the shop's equipment, safely get the tire ready to balance.

    a. Place the car securely on safety stands, or lift it with a hoist.

    b. Take the tire off the car. (This step may not be needed.)

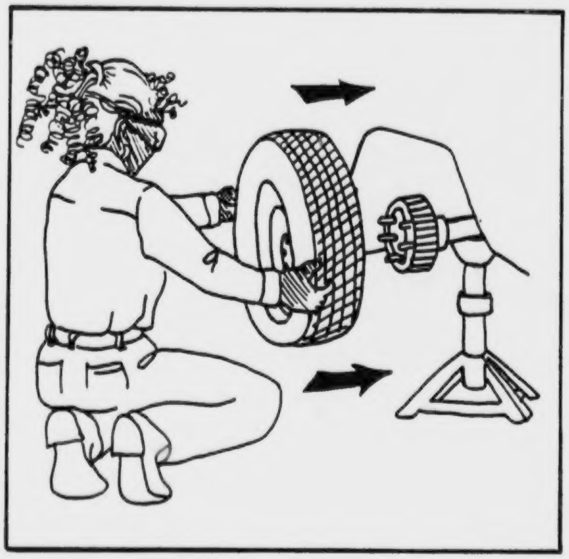
    c. Remove any gravel or mud from the tread or from the inside of the rim.





5. Balance the tire according to the machine specification.

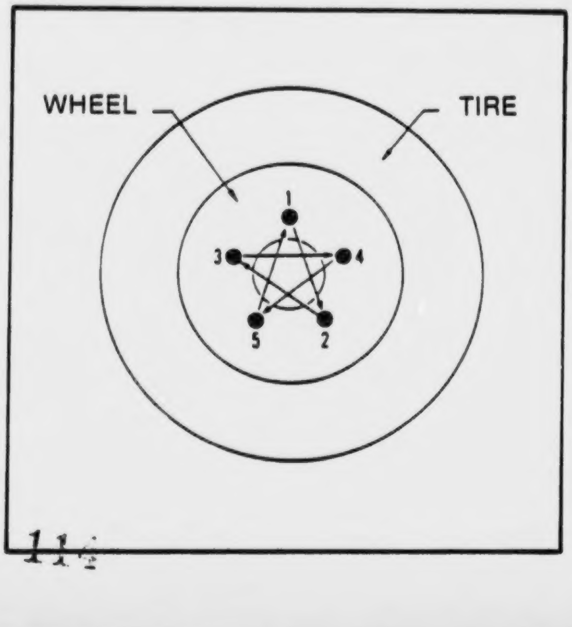
6. Make sure all weights on the wheel are securely installed.



7. Install the tire (if this step is needed.)

8. Lower the car.

9. Torque the lug nuts in a star pattern and install the wheel cover.



10. Have your instructor check your finished work.

11. Clean your work area and return all tools and equipment to their proper places.

DO SKILL SHEET 1

DO ACTIVITY SHEET 1

SKILL SHEET 1

Directions: Complete the following statements with one of the words or phrases listed below. If you are not sure of the answer, refer to the text for help.

1. A tire (can, cannot) be in static balance but not be in dynamic balance at the same time.

2. (Balance, Imbalance) occurs when parts carry unequal weight or force; when they are uneven or unsteady.

3. Your shop has ____________ number of ways to balance a tire.

4. It (is, is not) okay to balance a worn-out tire.

5. It is (necessary, unnecessary) to remove rocks from the tread and mud from the rim before balancing a tire.

CHECKING TIRES AND WHEELS

ACTIVITY SHEET 1

1. See your instructor to get a car that needs a tire balanced.

2. Review the steps in this unit, look at the proper service manual and the manual for the tire balancer in your shop.

3. Have your instructor check your ability to use the shop's tire balancer.

4. Get the tools and equipment you need.

5. Complete the balancing procedure. (Wear proper eye protection.)

6. Type of Balancer Used ____________________

7. Number of tires balanced _________

8. Put away your tools and clean up the work area.

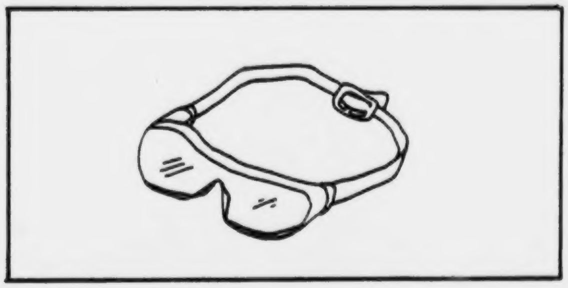
D. Tire Runout

The tires and wheels need to run fairly close to "true" as they roll down the road. In other words, the tires should not vibrate too much up and down or in and out.

Such vibration is known as "runout," and too much runout makes the car shake.

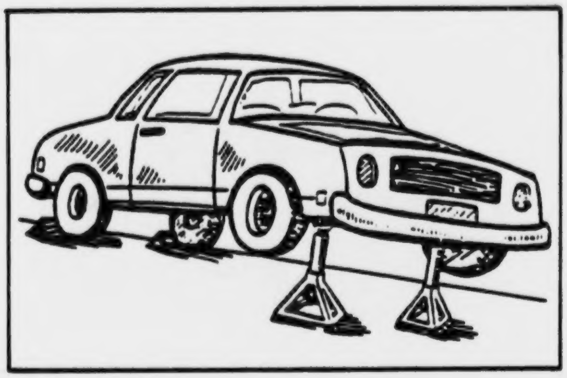
You will need the following equipment:

Jack or hoist
Safety stands
Hand tools
Lug wrench
Runout gauge
Tire marker
Air hose
Tire pressure gauge
Tire inflation tool



1. Steps of procedure for a radial runout check

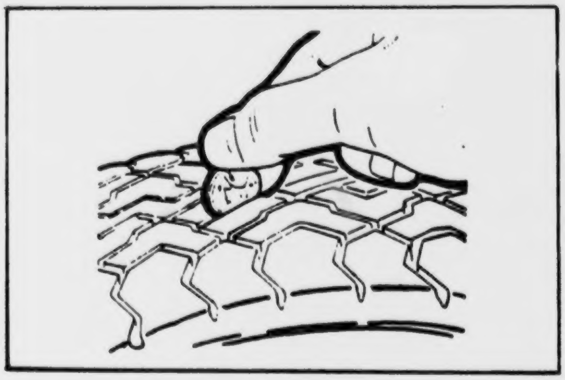
a. Wear safety glasses.



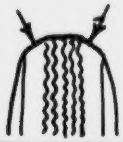
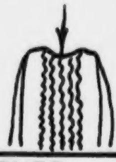
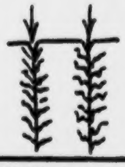
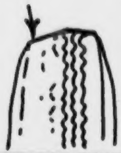
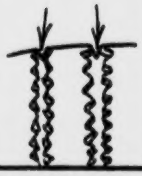
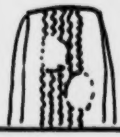
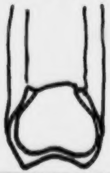
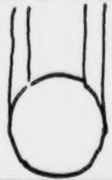
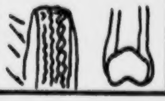
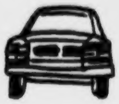
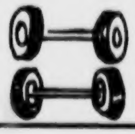
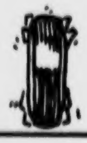
b. Raise the vehicle and place it on safety stands according to the jack and car maker's instructions.

c. Spin the tire to make sure it spins freely.

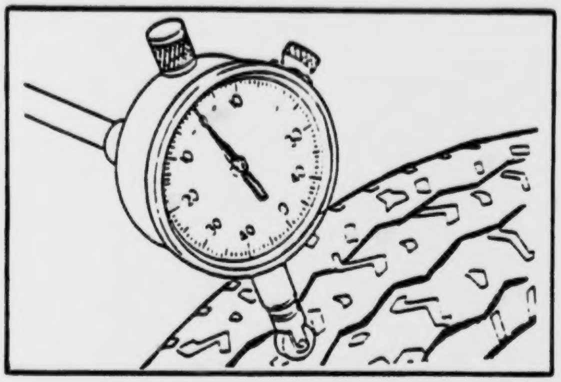
d. Check the condition of the tire.



- Measure the tread depth. Its minimum depth should be 3/32 inches.
- Examine the tread for unusual wear patterns.
- Examine the tread and sidewall for cracks and knots.

CONDITION	RAPID WEAR AT SHOULDERS 	RAPID WEAR AT CENTER 	CRACKED TREADS 	WEAR ON ONE SIDE 	FEATHERED EDGE 	BALD SPOTS 
CAUSE	UNDER INFLATION 	OVER INFLATION 	UNDER INFLATION EXCESSIVE SPEED 	EXCESSIVE CAMBER 	INCORRECT TOG 	WHEEL UNBALANCED 

e. Check and adjust the wheel bearings if they are serviceable. (Wheel bearing service is not covered in this unit. See your instructor for more information.)



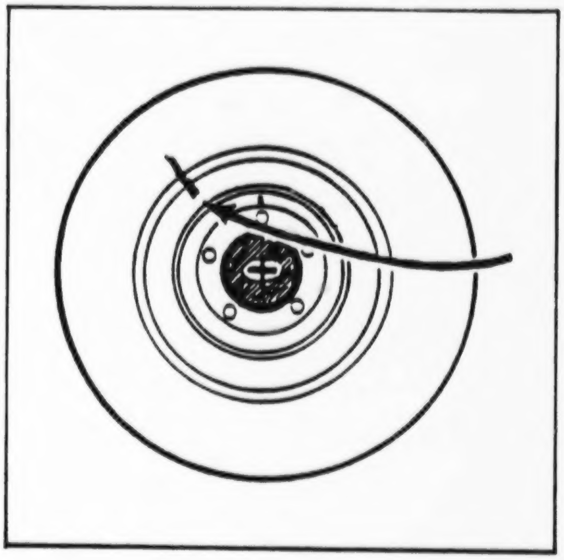
f. Check and adjust the air pressure in the tire.

g. Place the runout gauge roller on the center rib of the tire.

h. Zero the gauge.

i. Rotate the tire to find the low spot on the tread. Again zero the dial of the runout gauge.

j. Rotate the wheel again and mark the high spot (1) on the tread and (2) on the nearest lug bolt.



If the runout is within specifications, go to the lateral runout test.

If the runout is not within specifications, rotate the tire two lug bolts and repeat the test. (Torque the lug nuts to specification.)

k. If the runout is still not within specifications, remove the tire/wheel assembly. Using a tire machine, rotate the tire one-half turn on the wheel.

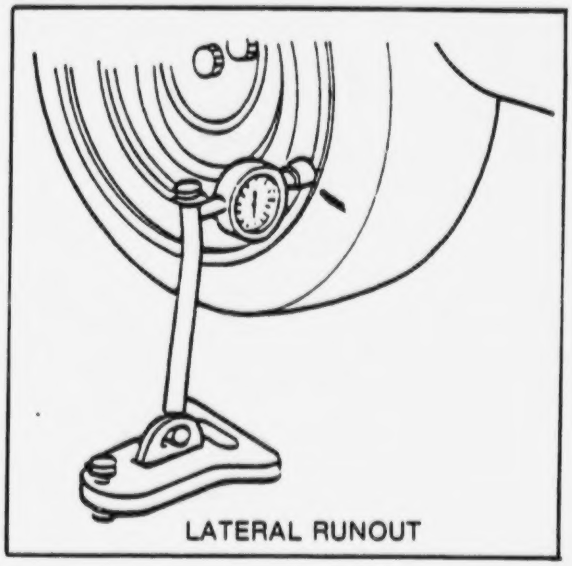
Install the tire/wheel assembly and repeat the test. (Torque the lug nuts to specification.)

2. Steps of Procedure for a Lateral Runout Check

a. Place the runout gauge in the center of the tire's side wall for the lateral runout check.

b. Zero the gauge.

c. Rotate the wheel to find the low spot on the tire sidewall. Mark the low spot on the sidewall as you zero the runout gauge.



LATERAL RUNOUT

d. Rotate the tire again and mark the high spot on the tire sidewall and the tire's nearest lug bolt.

If the tire runout measures within specifications, balance it.

e. If the runout is not within specifications, remove it and align the tire's low spots with the marked lug bolt and repeat the test.

f. If the runout is still not within specifications, repeat steps "a" through "d" on the outer edge of the wheel.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

SKILL SHEET 2

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, refer to the text for help.

1. Too much runout (will, will not) cause the car to vibrate.

2. Radial runout (is, is not) measured on the side wall of the tire.

3. Before you check the tire runout, what three conditions should you check for on the tire?

   a.____

   b.____

   c.____

4. Wheel bearings (should, should not) be adjusted before checking tire runout.

ACTIVITY SHEET 2

1. See your instructor to get a car that needs its tire runout checked.
2. Review the procedure outlined in this unit, appropriate service manual and the instructions that come with the runout gauge.
3. Get the tools and equipment you need.

WEAR SAFETY GLASSES.

4. Complete the procedure for checking tire runout.
5. Record the final runout reading for the tires you checked.

LF	RF
Radial tire ____________________	Radial tire ____________________
Lateral tire ____________________	Lateral tire ____________________
Lateral wheel ____________________	Lateral wheel ____________________
LR ____________________	RR ____________________
Radial tire ____________________	Radial tire ____________________
Lateral tire ____________________	Lateral tire ____________________
Lateral wheel ____________________	Lateral wheel ____________________

Put away your tools and clean up the work area.

CHECKING TIRE AND WHEEL RUNOUT AND BALANCING TIRES

UNIT REVIEW

1. Radial runout can be checked with which tool?
   a. Dial indicator
   b. Feeler gauge
   c. Micrometer

2. Radial runout is checked on
   a. the center rib of the tires.
   b. the tire side wall, close to the rim.
   c. the wheel, next to the lug bolts.

3. Radial and lateral runout will put the wheel assembly out of balance.
   TRUE FALSE

4. A tire is statically balanced when its weight is distributed equally around the the tire's spindle.
   TRUE FALSE

5. A tire is dynamically balanced when its weight is distributed equally around the tire's spindle.
   TRUE FALSE

6. Never balance a worn-out tire.
   TRUE FALSE

7. Mud buildup on the inside of a wheel can affect
    a. Lateral runout
    b. Radial runout
    c. Tire balance

8. A tire that does not run "true" may cause the car to vibrate or shake.
    TRUE FALSE

9. Wheel tramp is the same as
    a. shimmy
    b. tire hopping
    c. static balance

10. Tire imbalance will not shorten the life of a tire.
    TRUE FALSE

CHECKING TIRE AND WHEEL RUNOUT AND TIRE BALANCING

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Raised car and mounted it on jack stands properly			
2. Balanced a tire electronically			
3. Balanced a tire with a spin balancer			
4. Balanced a tire with a bubble balancer			
5. Mounted and torqued a tire to manufacturer's specifications			
6. Performed a radial runout check			
7. Performed a lateral runout check			

Satisfactory - should move on ☐

Should repeat this unit ☐

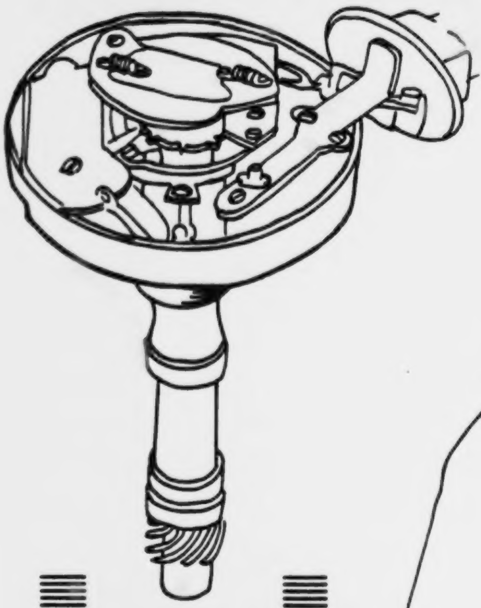
______________________________ Student's Signature/Date

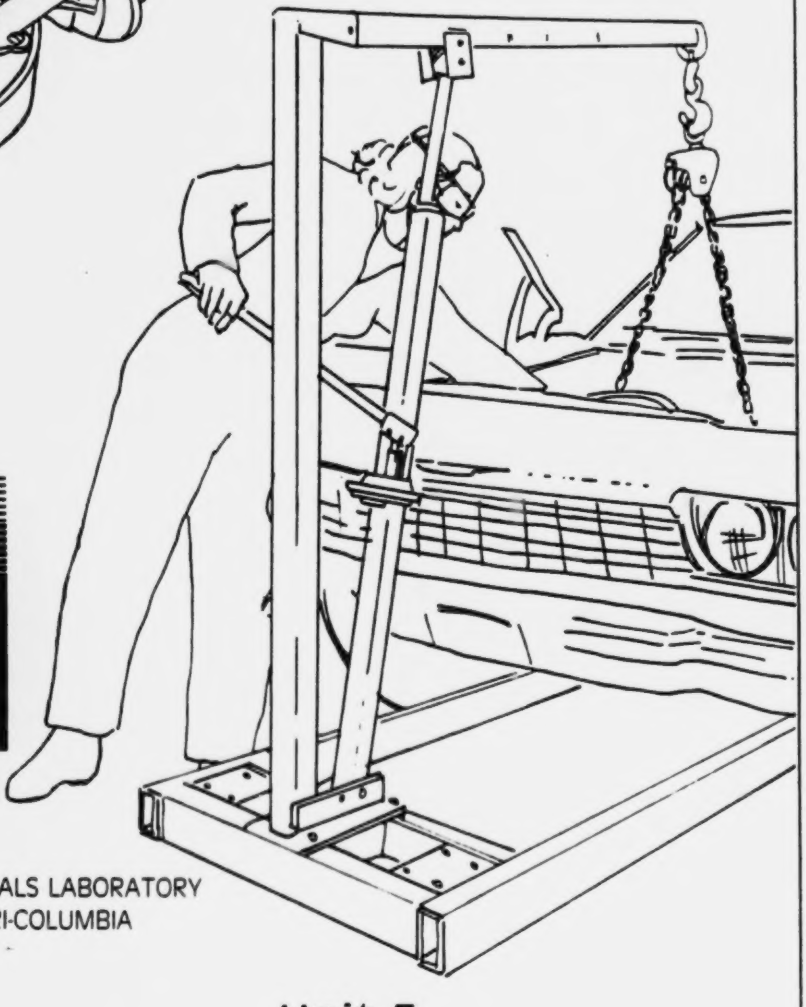
______________________________ Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units





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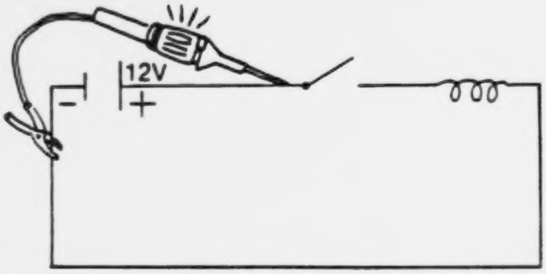

Unit 5

Checking and Replacing Shock Absorbers

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CHECKING AND REPLACING SHOCK ABSORBERS

INTRODUCTION

Shock absorbers are an important part of the suspension system. When shocks fail, people in the car can have a very unpleasant ride or an accident. This unit will show you how to test and service shock absorbers.

UNIT OBJECTIVE

After you complete this unit, you will be able to diagnose problems in, service and replace shock absorbers.

SPECIFIC OBJECTIVES

After completing this unit you will be able to specifically:

1. Describe the function of a shock absorber.
2. Inspect and test a shock absorber for signs of wear.
3. Replace a shock absorber.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Aeration** - the creation of air bubbles in a liquid. Aeration can occur in the shocks during heavy use and can reduce their effectiveness.

2. **Air shock** - a type of rear hydraulic shock absorber that has an air chamber between the shock absorber body and dust shield. "Air adjustable" shock absorbers are used to maintain the vehicle suspension height with heavier loads.

3. **Gas Shock** - a type of hydraulic shock absorber that has freon or nitrogen gas in the area above the shock's hydraulic fluid. The freon or nitrogen gas reduces aeration.

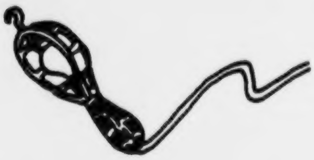
4. **Jounce** - the downward motion of the car body, during which the spring and shock absorber contract.

5. **Rebound** - the upward motion of the car body, during which the spring and shock absorber stretch.

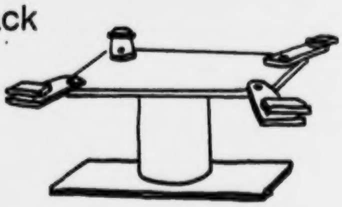
6. **Shock absorber** - a hydraulic device that reduces "spring action" (unwanted up-and-down movement) of the car.

Equipment

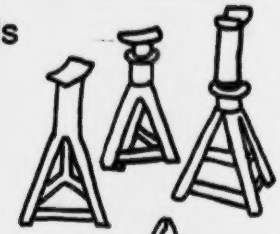
Drop light



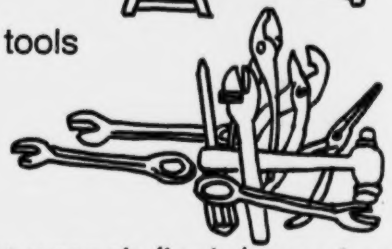
Hoist or jack



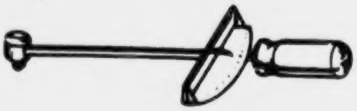
Safety stands



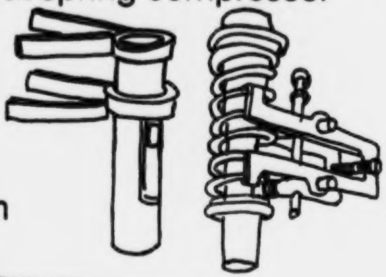
Hand tools



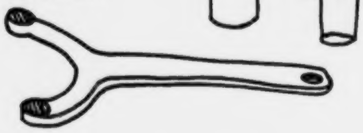
Torque wrench (Inch/pound and foot/pound)



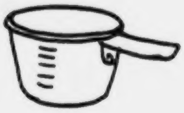
MacPherson strut spring compressor



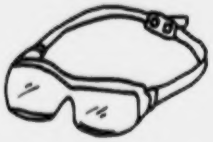
Spanner wrench



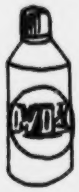
Measuring cup



Safety glasses



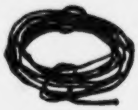
Penetrating oil



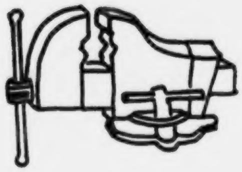
Service manuals

Permanent marker

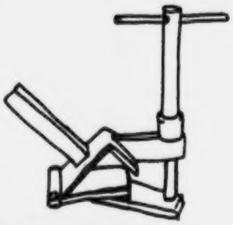
Mechanics' wire



Vise



Strut clamp



Seat covers and Fender covers

B. Shock Absorbers

1. Purpose

The automobile suspension system is designed to provide a smooth and safe ride. The suspension system, when working properly, reduces the up-and-down movement of the rolling car.

At each wheel, there is a spring between the car's frame and the suspension system. Each spring compresses when its wheel hits a bump and expands when its wheel drops into a hole.

Springs are made of very elastic steel. The elastic steel allows the springs to keep moving in and out (contracting and expanding) several times after the wheels hit a hole or bump. If the shaking movement (vibration) is not controlled by shock absorbers, an unpleasant or unsafe ride results.

Shock absorbers are hydraulic units that reduce unwanted spring action and body movement of the car.

When the shock absorbers work properly, they absorb the energy from the springs. The energy is changed to heat energy in the shock absorbers and later escapes into the air.

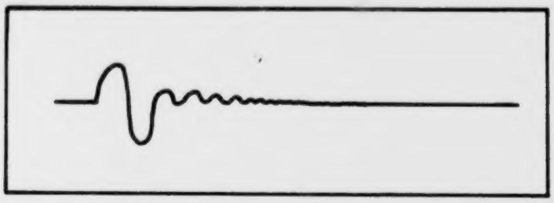
2. Operation

The shock absorber is a hydraulic device that dampens the action of a spring. When a car hits a bump or pothole, the impact is absorbed by the spring.

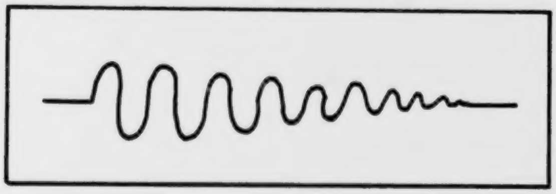
To get a smooth ride and to allow the spring to do its job, you must always install the correct shock on the car. It is important to install shock absorbers of the correct "stiffness."

If a shock absorber is too "soft," it will act like a worn-out shock absorber. Worn-out shocks do not control the action of the springs properly. If the action of the springs is not controlled, the car bounces too much.

Normal Car Movement



Excessive Body Movement
(worn shocks or too soft shock)



Likewise, if a shock absorber is too "stiff," it will limit the action of the springs. If spring action is limited, the car takes all of the force of impact with the road. This extra force creates a rough ride and is very hard on the steering and suspension components.

The cost of a replacement shock absorber can vary by several dollars. It is very important that shock absorbers be the right "stiffness" and that they meet or exceed the original equipment manufacturer's specifications for construction.

Different car makers have different methods of mounting shock absorbers. Methods will differ from model to model, but one of these five mounting styles is most often used.

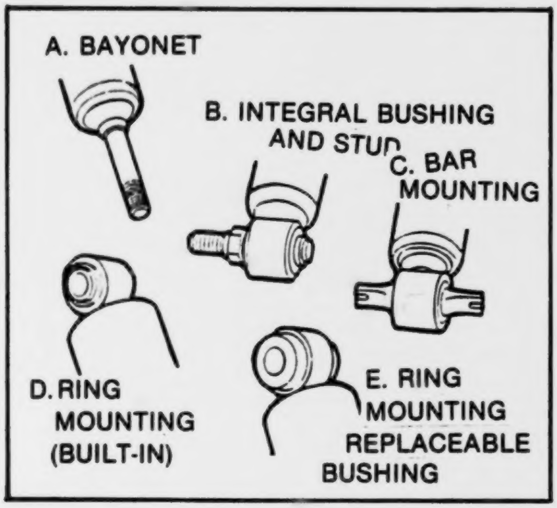
a. bayonet

b. integral bushing and stud

c. bar mounting

d. ring mounting (built-in)

e. ring mounting (replaceable bushings)


A. BAYONET
B. INTEGRAL BUSHING AND STUD
C. BAR MOUNTING
D. RING MOUNTING (BUILT-IN)
E. RING MOUNTING REPLACEABLE BUSHING

3. Inspection

Note: Always wear safety glasses when working on cars.

The life of a shock absorber is determined by the conditions of its use and its quality. A shock absorber usually lasts from 15,000 miles to 50,000 miles or more. A complete inspection of a car's shock absorbers consists of three to five tests and should start with a safety inspection of the steering and suspension system.

NOTE: Steering and suspension system inspection is not covered in this unit. See your instructor for more information.

You will need the following equipment:

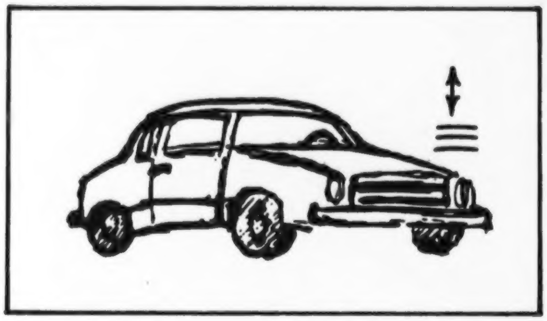
Hoist or jack
Hand tools
Safety glasses
Drop light
Safety stands
Fender covers
Seat covers
Service manual

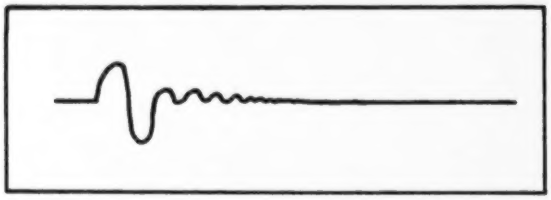
a. Test 1 - Bounce Test

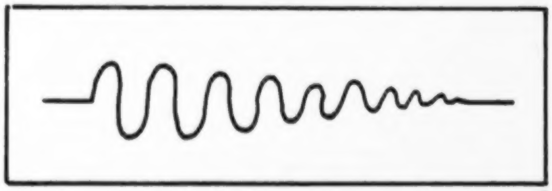
- Bounce one corner of the car up and down several times by pulling and pushing on the bumper.

- Release the bumper and count the number of up-and-down movements before the car body stops moving.

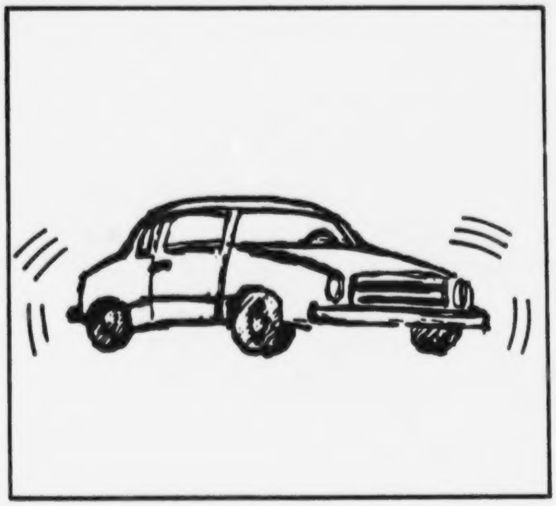
If two or more up-and-down movements occurred, or if rattling noises came from the shock, it should be replaced.







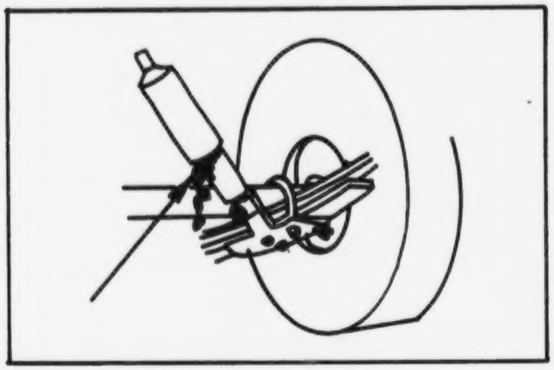
b. Test 2 - Road Test



- On a smooth, straight and dry section of road, drive the car at 8-14 mph and lightly apply the brakes several times. (Always wear safety belts.)
- If the car's body weight shifts suddenly, or if the car rocks from front to rear, one or both pairs of the car's shock absorbers are bad.

c. Test 3 - Visual Inspection

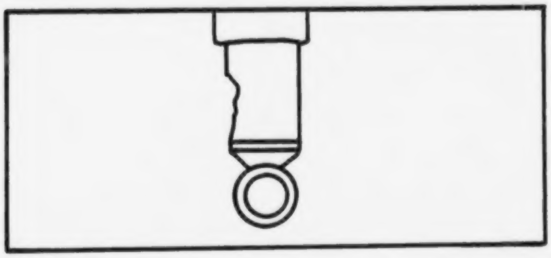
- Place the car securely on safety stands or lift it with a hoist.



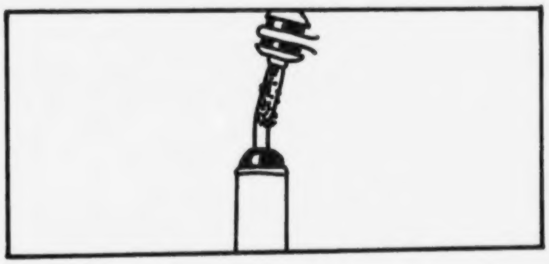
- Use a drop light to examine the shock absorber for:

(1)Too much oil leakage

NOTE: A small amount of oil seepage is okay.

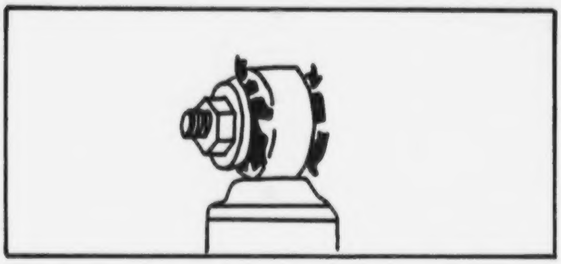


(2)Body damage

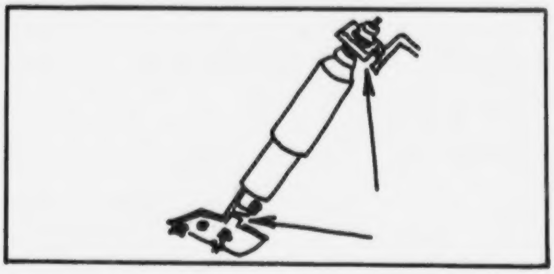


(3)A bent or rusted rod

(4) Defective rubber bushings (top or bottom)



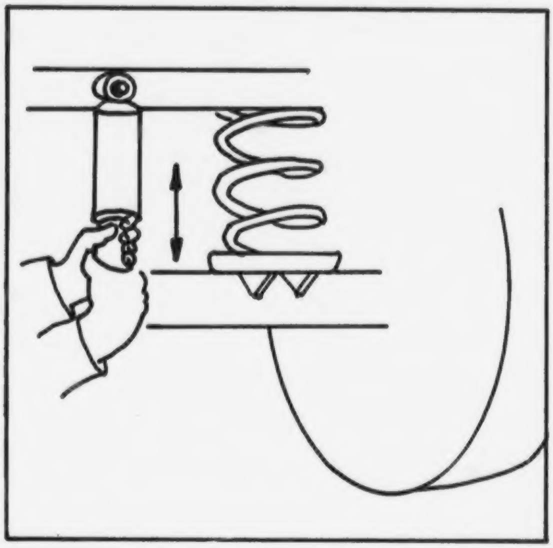
(5) Broken or cracked mounts



d. Test 4 - Operational test

If you think you may have a bad shock absorber, try this test on the shocks.

- With the car still raised from the visual inspection test, release the lower shock absorber mounting.
- Work the shock's piston in and out. The piston should move smoothly and easily. It should travel its full distance with slightly more resistance when it expands than when it contracts.



DO SKILL SHEETS 1 and 2

DO ACTIVITY SHEET 1

SKILL SHEET 1

Directions: Complete the following statement with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

hydraulic
suspension system
road test
spring
hard
gas shock absorber
shock absorber
soft
bounce test

1. The ______________ supports the weight of the car.
2. The _________________________ is a special type of shock absorber used to reduce aeration.
3. A shock absorber is a __________________ device.
4. A ______________ shock absorber will cause a rough ride.
5. In a _________________________, if two or more up-and-down movements occur, the shock should be replaced.

SKILL SHEET 2

SHOCK ABSORBER INSPECTION

Directions: Before inspecting a car's shock absorbers, answer the following questions. If you are not sure of an answer, refer to the text for help.

1. A shock absorber (will, will not) wear out.

2. If the car oscillates five times after released during the bounce test, the shock absorber is (okay, bad).

3. During the road test the car should be driven (8-12, 15-18, 30-35) mph.

4. A small amount of oil seepage around the shock absorber seal is (normal, abnormal).

5. List the four mechanical problems to look for during visual inspection.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

SHOCK ABSORBER INSPECTION

ACTIVITY SHEET 1

1. See your instructor to get a car that needs its shock absorbers inspected.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed.

4. Complete the inspection procedure (Wear eye protection).

5. Record results.

LF ____

RF ____

LR ____

RR ____

6. Put away your tools and clean up the work area.

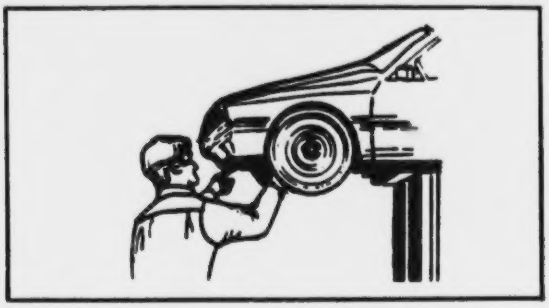
C. Replacing Front or Independent Rear Shock Absorbers

Always wear safety glasses.

NOTE: Always change shock absorbers in pairs--front pair or rear pair

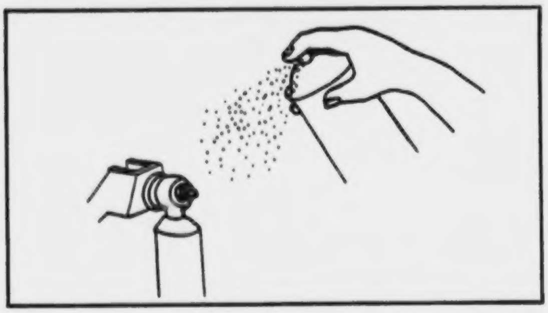
You will need the following equipment:

Hoist or jack
Penetrating oil
Hand tools
Fender covers
Drop light
Seat covers
Safety stands
Service manual
Safety glasses

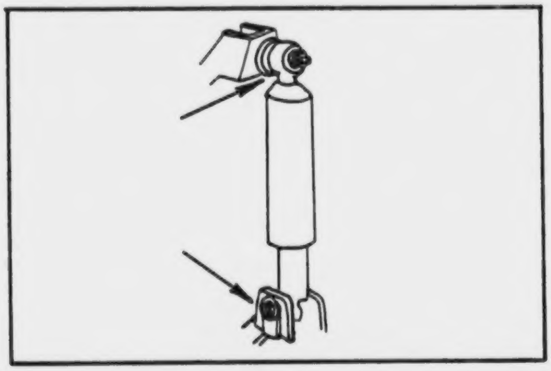


1. Place the car securely on safety stands or lift it with a hoist.

   (On some cars, the shock absorbers are mounted under the hood. If so, it is often easier to remove the top mounting nut before the car is raised)

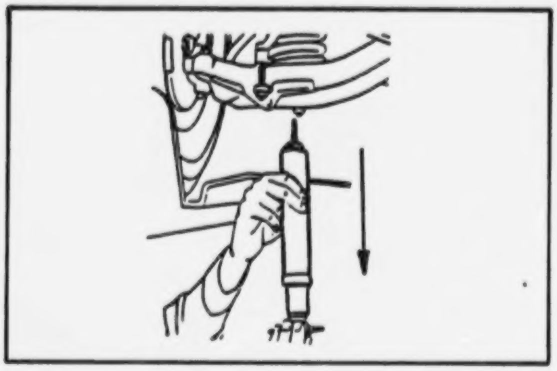


2. Spray the mounting hardware with penetrating oil.

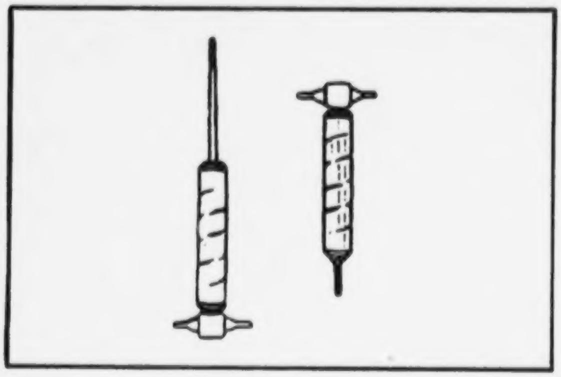


3. Remove the upper mounting nut, if you haven't already done so.

4. Remove the lower mounting attachment.



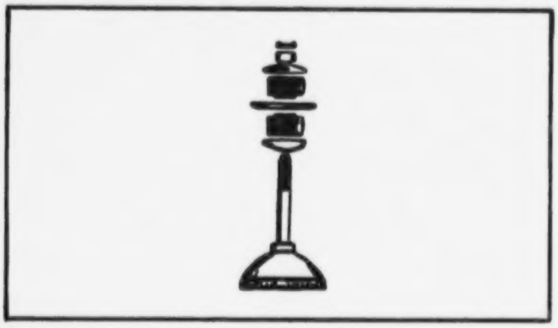
5. Remove the old shock absorber and old grommets.



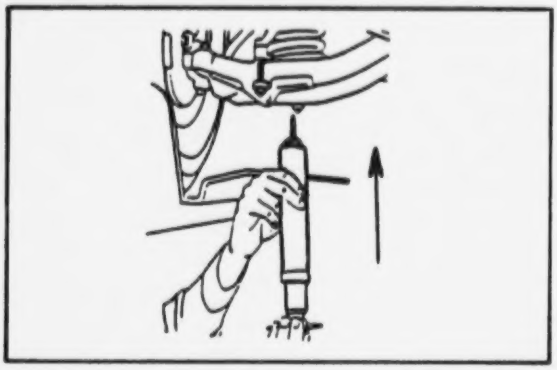
6. Purge the new shock absorbers.

a. Turn each shock right side up and extend it to maximum length.

b. Turn each shock upside down and compress it to minimum length.

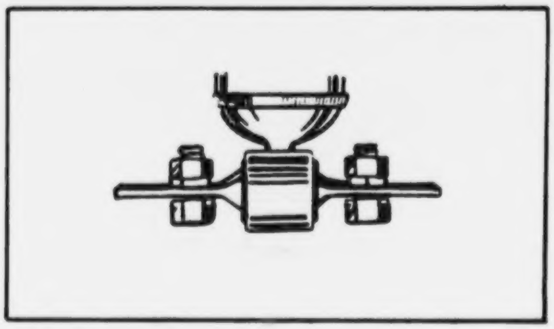


7. Put the washers and grommets in their proper position. (See the instructions in the box.)

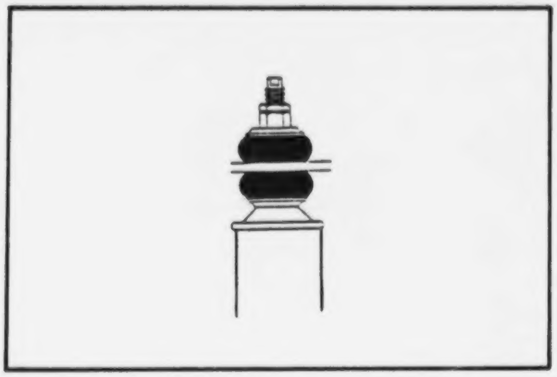


8. Install the new shock absorber.

9. Hook up the lower mounting attachment. (Do not make it too tight.)

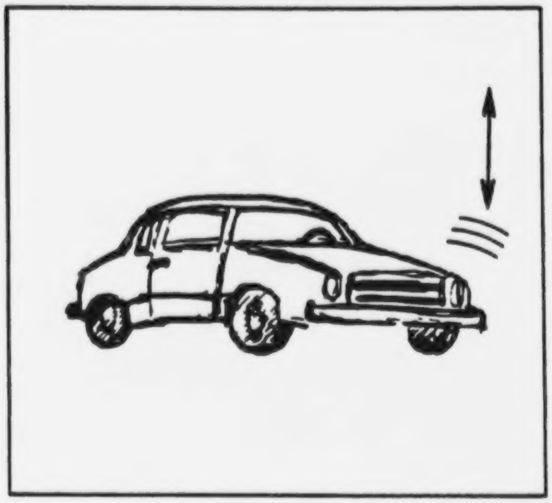


10. Hook up the upper mounting attachment. (Do not make it too tight.)



11. Lower the car to the ground.

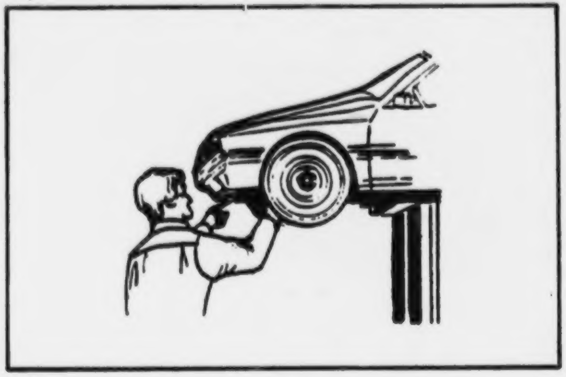
12. Bounce the car to make sure its shock absorbers work freely.



13. Put away your equipment and clean up the work area.

D. Replacing Rear Shock Absorbers

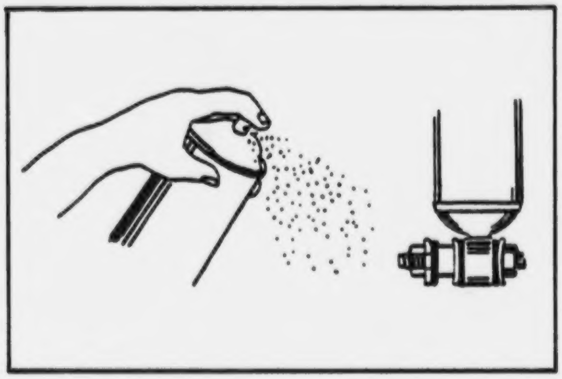
Wear safety glasses.



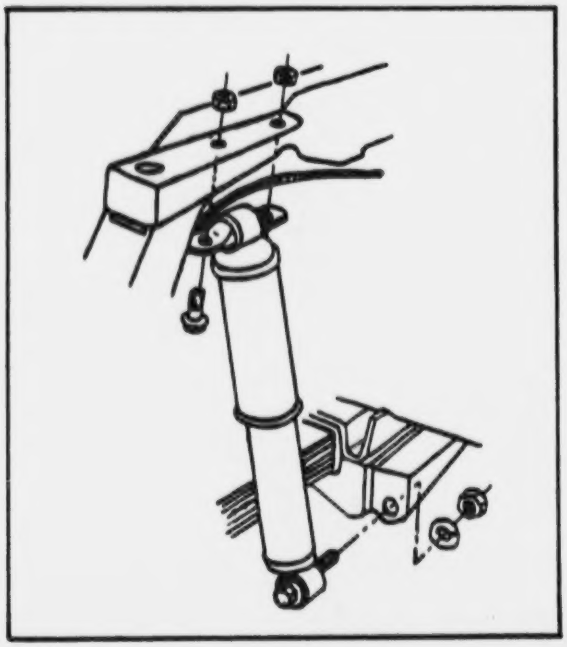
1. Place the car securely on safety stands or lift it with a hoist.

   NOTE: Always position two safety stands under the axle housing so the car cannot fall and hurt you.

   NOTE: Service procedure for independent rear suspension systems is outlined in section C.



2. Spray the mounting hardware with penetrating oil.



3. Remove the upper mounting attachment.

4. Remove the lower mounting attachment.

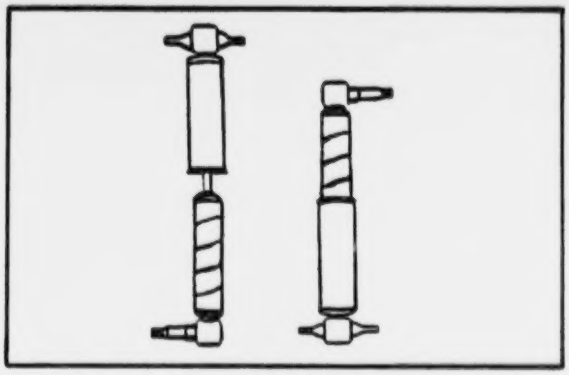
5. Remove the old shock absorbers and grommets.

142

6. Purge the new shock absorbers

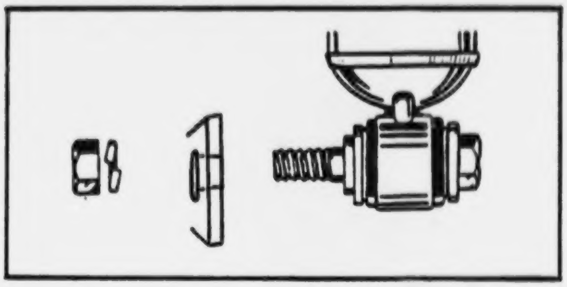
a. Turn the shock right side up and extend it to maximum length.

b. Turn the shock upside down and compress to minimum length.



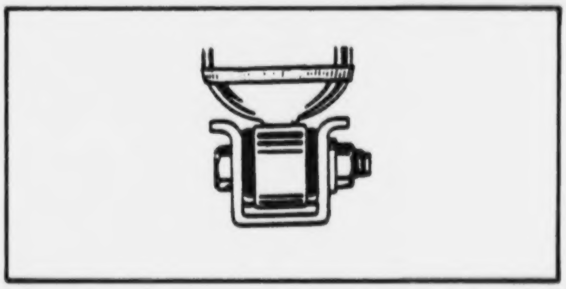
7. Put the washers and grommets in their proper position. (See the instructions in the box.)

8. Install the new shock absorber.



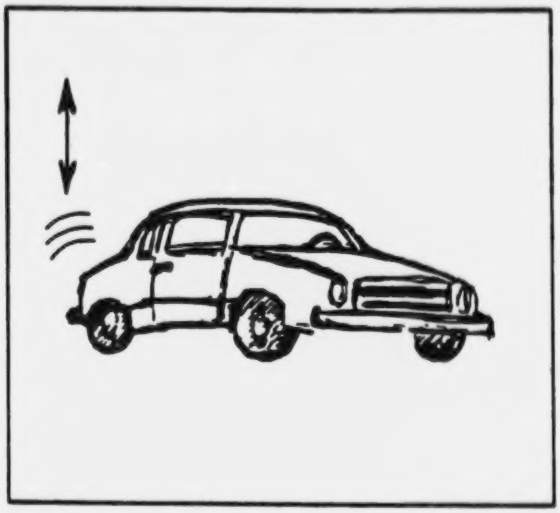
9. Hook up the lower mounting attachment. (Do not make it too tight.)

10. Hook up the upper mounting attachment. (Do not make it too tight. Do not stress or twist the rubber grommets.)



11. Lower the car to the ground.

12. Bounce the car to make sure the shock absorbers work freely.



13. Put away your equipment and clean up the work area.

DO SKILL SHEET 3

DO ACTIVITY SHEET 2

SKILL SHEET 3

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

grommet
left front
front pair of
front
shock
purge
rear

1. If the left front shock absorber is bad, the ______________ shock absorber(s) should be changed.

2. Shock absorbers in independent rear suspension systems are serviced almost the same way as the ________________ shock absorbers.

3. Be sure to _______________ the shock absorber before installation.

4. Extra care must be taken in the placement of the safety stands when changing the ______________ shocks so you are not hurt.

5. During replacement, care should be taken not to overflex the ____ .

SHOCK ABSORBER SERVICE

ACTIVITY SHEET 2

1. See your instructor to get a car that needs its shock absorbers changed.

   make of car __________
   year _____
   model __________

   Front _____ Rear _____ Both _____

2. Review the procedure outlined in this unit and the appropriate service manual for the car.

   NOTE: Service manuals may give you a specific procedure or method that will make the job easier.

3. Secure the tools, equipment and new shock absorbers (make sure the shock absorbers are the correct type for the car).

4. Complete the service procedure (Wear proper eye protection).

5. Bounce the car to make sure the shock absorbers work freely.

6. Put away your tools and equipment and clean up the work area.

CHECKING AND REPLACING SHOCK ABSORBERS

UNIT REVIEW

1. A shock absorber is a hydraulic device that reduces "spring action," or unwanted up-and-down movement of the car.

   a. True b. False

2. Which of the following is not a type of shock absorber?

   a. gas shock b. strut cartridge
   c. air shock d. coil spring

3. Shock absorbers do wear out. The service life is

   a. 2,000-5,000 miles b. 15,000-50,000 miles
   c. 80,000-100,000 miles d. 7-10 years

4. Shock absorbers should always be

   a. rotated every 5000 miles. b. changed in pairs.
   c. both a and b d. neither a nor b

5. It is important to install shocks that are

   a. extremely "hard." b. extremely "soft."
   c. both a and b d. neither a nor b

CHECKING AND REPLACING SHOCK ABSORBERS

PERFORMANCE CHECKLIST

Student ____________________ successfully performed the following tasks:

	Yes	No	Comments
1. Gathered necessary tools and equipment			
2. Put on his or her safety glasses			
3. Described the function of a shock absorber			
4. Inspected and tested shock absorbers			
5. Replaced shock absorbers			
6. Cleaned the work area and put away tools			

Satisfactory - should move on ☐

Should repeat this unit ☐

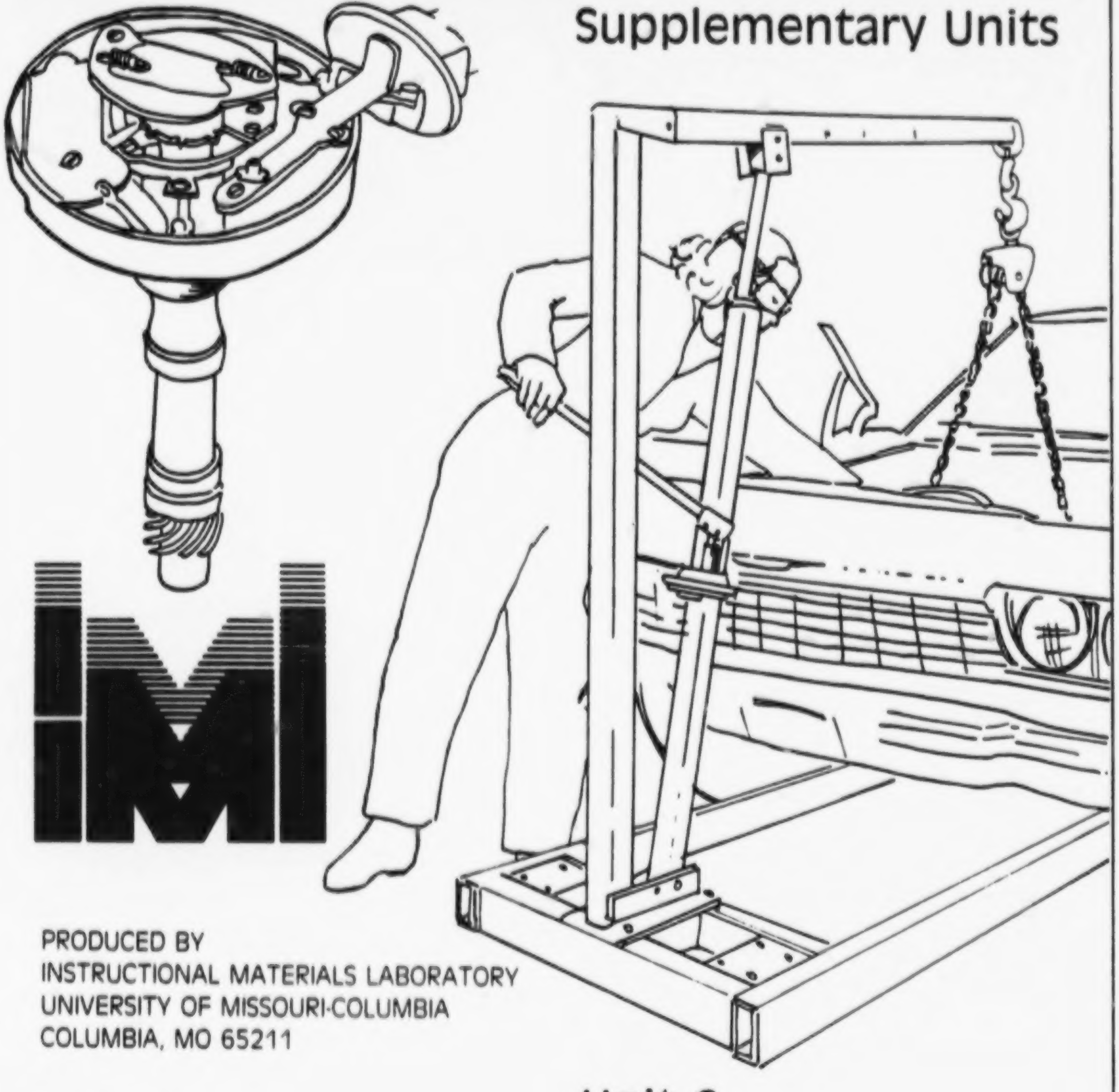
____________________ Student's Signature/Date

____________________ Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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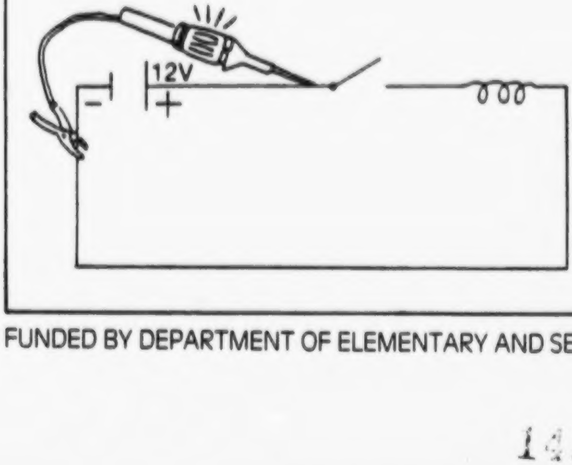

Unit 6

Checking and Repairing MacPherson Struts

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CHECKING AND REPAIRING MACPHERSON STRUTS

INTRODUCTION

The MacPherson strut suspension system was designed in the 1940s. The system has become popular during the last ten years. Most of today's unibody cars (cars with bodies that are separate from their frames) use MacPherson struts in front. A few models use MacPherson struts on the rear suspension system as well.

The MacPherson strut suspension system has several advantages over other systems. It has fewer components, takes up less space and spreads the suspension load over a wider area of the car body.

UNIT OBJECTIVE

After you complete this unit, you will be able to diagnose problems in, service and replace MacPherson struts.

SPECIFIC OBJECTIVES

After completing this unit you will be able to specifically:

1. Describe the function of a MacPherson strut.
2. Inspect and test a MacPherson strut for signs of wear.
3. Replace a MacPherson strut.
4. Service a MacPherson strut.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

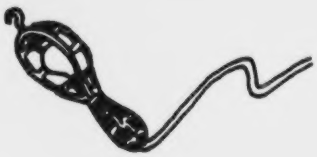
1. **MacPherson strut** - a suspension system that combines several suspension components, spring and shock absorber into a single device.

2. **Strut cartridge** - the name given to the shock absorber in a MacPherson strut.

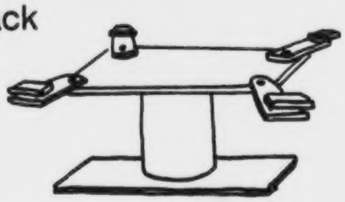
3. **Unibody** - a type of car in which the body is separate from the frame.

Equipment

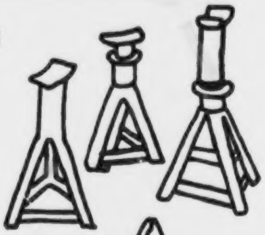
Drop light



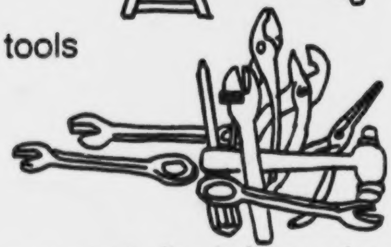
Hoist or jack



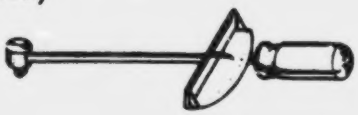
Safety stands



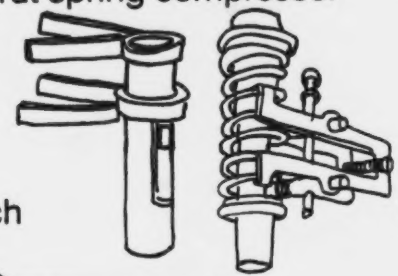
Hand tools



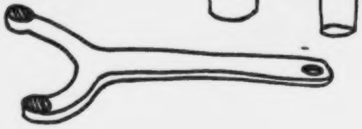
Torque wrench (Inch/pound and foot/pound)



MacPherson strut spring compressor

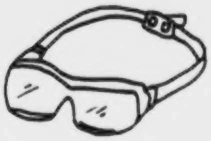


Spanner wrench



Measuring cup

Safety glasses



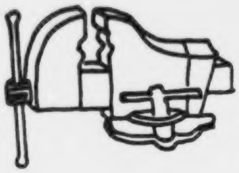
Penetrating oil

Service manuals

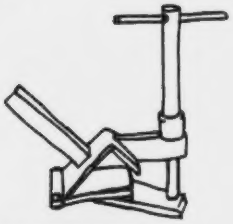
Permanent marker

Mechanics' wire

Vise



Strut clamp



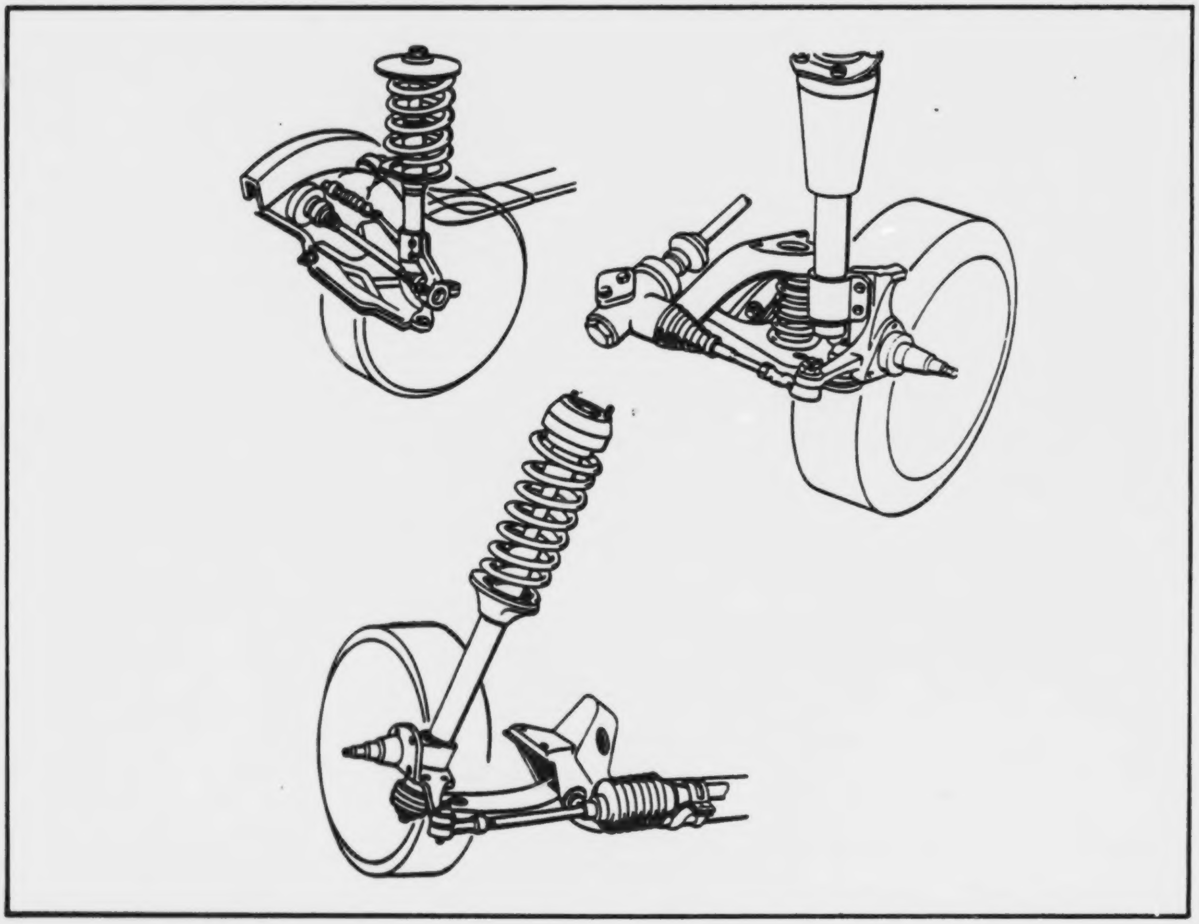
Seat covers and Fender covers

B. Procedures for MacPherson Struts

The MacPherson strut is a special type of suspension system that combines, in a single device

(1)several suspension components,
(2)a spring and
(3)a shock absorber.

The MacPherson strut system is made up of a strut, coil spring, upper mount, stabilizer (antiroll bar) and shock absorber. Most manufacturers call the MacPherson strut's shock absorber the "shock cartridge." MacPherson struts should only be changed in pairs (front and rear).



1. Inspection

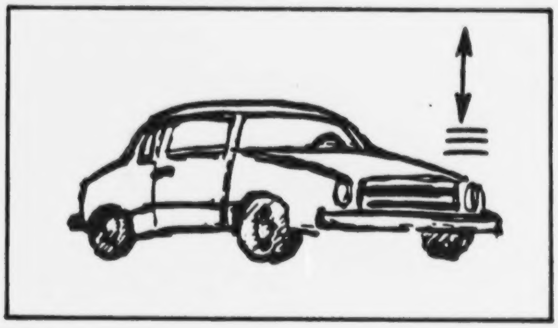
Always wear safety glasses when inspecting cars.

a. The life of the shock absorber in the MacPherson strut is determined by the conditions of use and its quality. A shock cartridge in the MacPherson strut should last from 15,000 miles to 50,000 miles or more. A complete inspection of the MacPherson strut consists of three to five tests and should start with a safety inspection of the steering and suspension system. (NOTE: Steering and suspension system inspection is not covered in this unit. See your instructor for more information.)

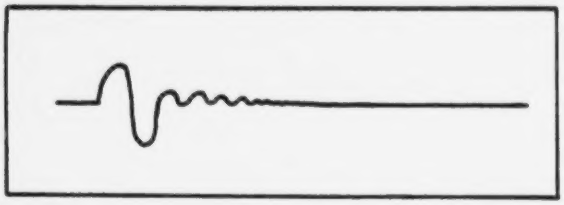
You will need the following equipment:

- Hoist or jack
- Safety glasses
- Drop light
- Seat covers
- Safety stands
- Service manual

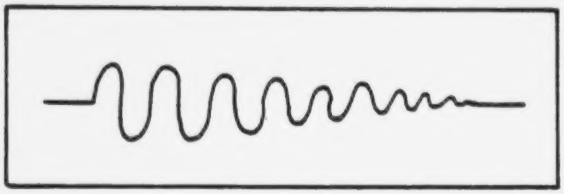
(1) Test 1 - Bounce test



- Bounce one corner up and down several times by pushing and pulling on the bumper.



- Release the bumper and count the number of times the car body moves up and down until it stops.

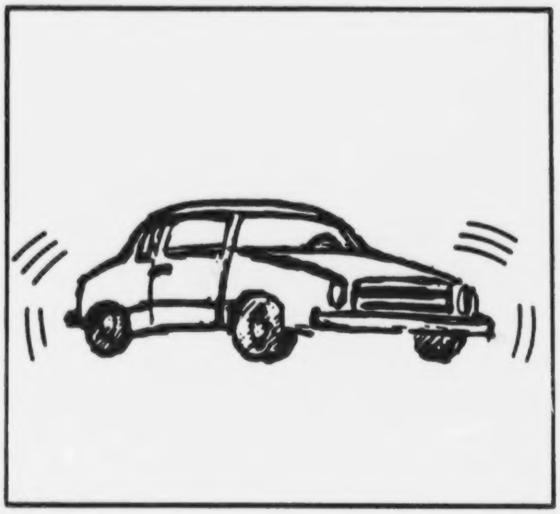


- If you count two or more up-and-down movements, or if rattling noises come from the struts, they should be serviced.

(2) Test 2 - Road Test

- On a smooth, straight and dry section of road, drive the car at 8-14 mph and lightly apply the brakes several times.

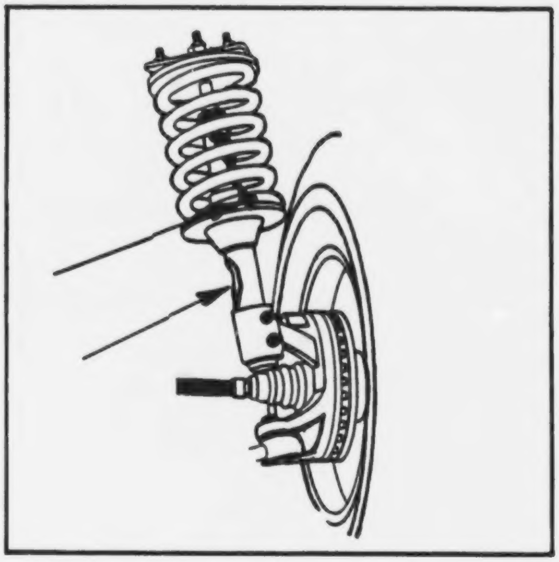
- If you feel a sudden shift in the car's body weight, or if the car rocks from front to rear, at least one of its pairs of shock absorbers is bad.



(3) Test 3 - Visual Inspection

- Place the car securely on safety stands or lift it with a hoist.

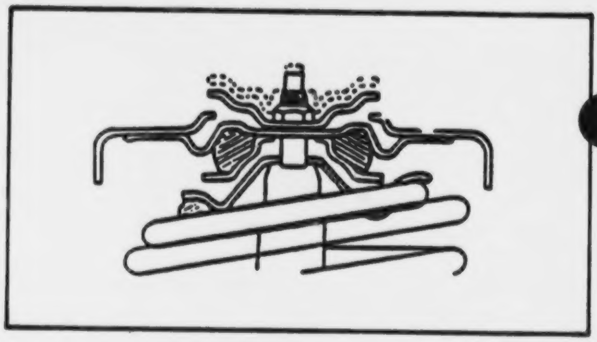
- Use a drop light to examine the MacPherson strut for:



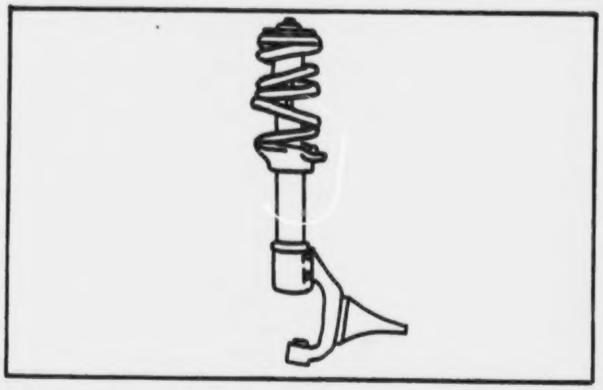
Excessive oil leakage

Body damage

Defective upper mount



Ride height
(Broken or weak spring)



(4) Test 4 - Bent MacPherson strut

To check for a bent MacPherson strut, you measure, with the shop's alignment equipment, the change in swing camber angle. (NOTE: Alignment is not covered in this unit. See your instructor for more information.)

DO SKILL SHEET 1

DO ACTIVITY SHEET 1

150

MACPHERSON STRUT INSPECTION

SKILL SHEET 1

Directions: Before going to a car and inspecting the MacPherson struts, answer the following questions. If you are unsure of an answer, go back to the text to find it.

1. A MacPherson strut (will, will not) wear out.
2. During a bounce test, if the car moves up and down five times after being released, the MacPherson strut (is, is not) in need of service.
3. During the road test, the car should be driven (8-12, 15-18, 30-35) mph.
4. The shock absorber in a MacPherson strut (is, is not) called a shock cartridge.
5. The test for a bent MacPherson strut (does, does not) require special alignment equipment.

MACPHERSON STRUT INSPECTION

ACTIVITY SHEET 1

1. See your instructor to get a car that needs the MacPherson struts inspected.
2. Review the procedure outlined in this unit and in the appropriate service manual for the car.
3. Secure the tools and equipment needed.
4. Complete the inspection procedure (Wear eye protection).
5. Record your results.

LF ______________________________

RF ______________________________

LR ______________________________

RR ______________________________

6. Put away your tools and equipment and clean up the work area.

C. Servicing MacPherson Struts

There are two styles of MacPherson struts: (1)those with a shock cartridge that can be replaced (serviceable) and (2)those that are made of a single unit (nonserviceable).

First, we will remove and install the MacPherson strut on the car. Then we will remove and install the spring inside the MacPherson strut and service the strut cartridge.

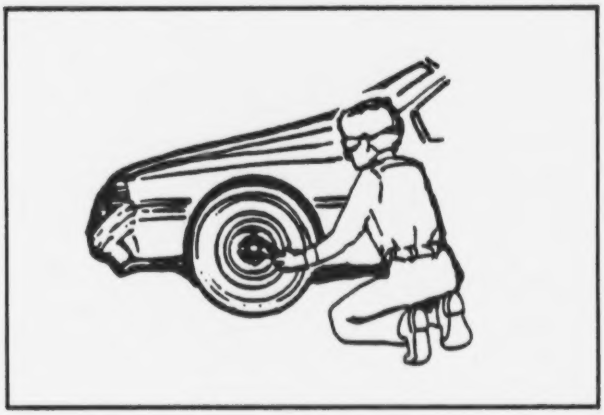
You will need the following equipment:

Service manual
Safety stands
Penetrating oil
Safety glasses
Drop Light
Hand tools
Torque wrench
Hoist or jack
Mechanics' wire
Permanent marker

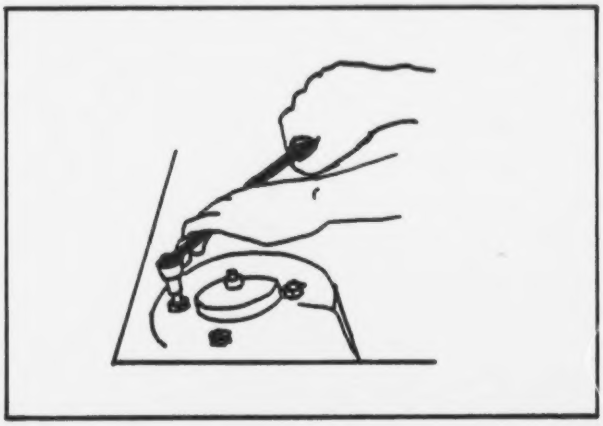
1. Strut Removal and Installation

Always wear eye protection.

(Removal)
a. Remove the wheel cover and loosen all lug nuts.

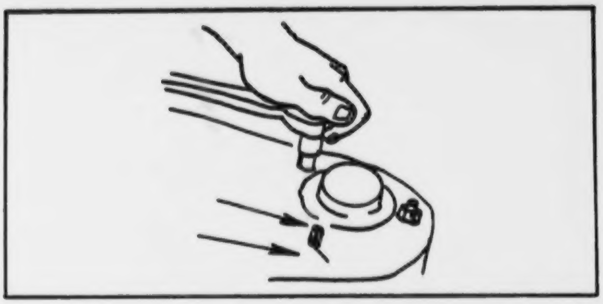


b. Loosen the three bolts where the MacPherson strut attaches to the strut tower. Remove only two of them.



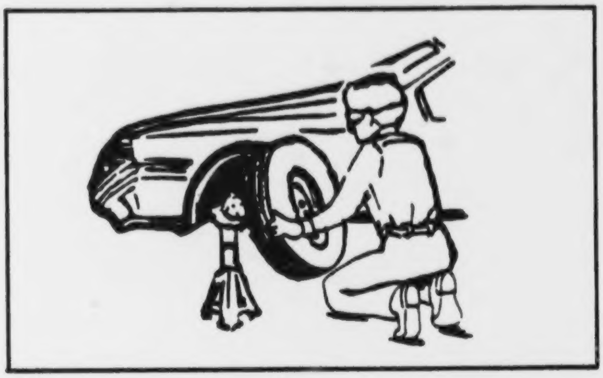
CAUTION: Never remove the center nut on the MacPherson strut because the assembly could fly apart and hurt you.

c. Choose a stud and make two marks -- one on the stud and another beside it. The marks will show you how to put the assembly back together the same way you took it apart.

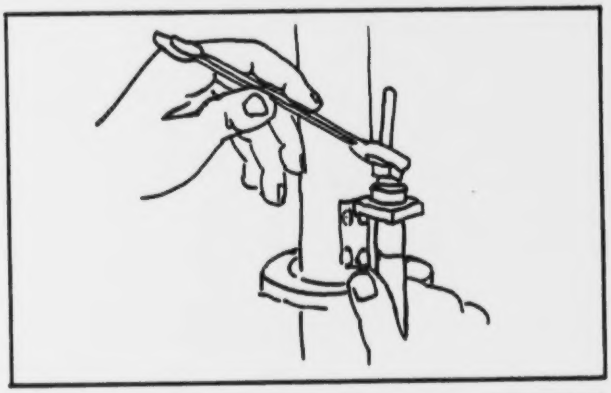


d. Place the car securely on jack stands or lift it with a hoist.

e. Remove the lug nuts and the tire.

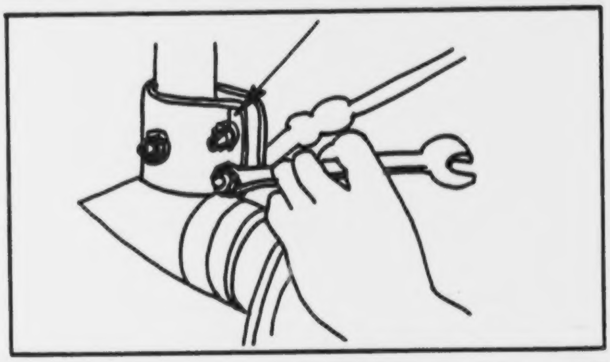


f. Remove the brake line and plug. NOTE: THIS STEP IS NECESSARY ON ALL CARS.

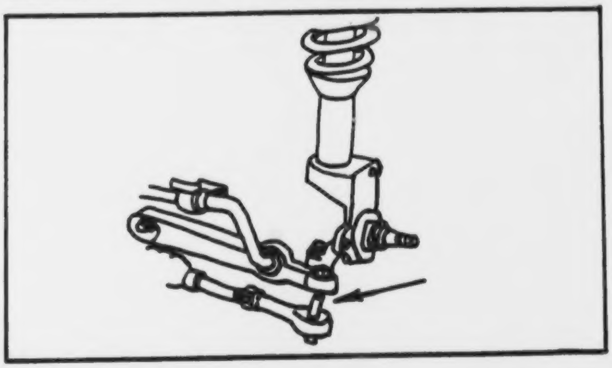


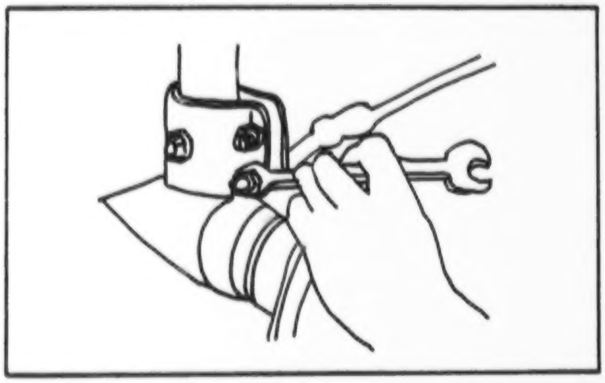
g. Mark the lower assembly so you will know how to put it back together when you finish. The assembly must be placed in the exact position it was in before the assembly was taken apart.

(Note that three or four different methods are used to attach the strut at the lower end. GM's method is shown here.)

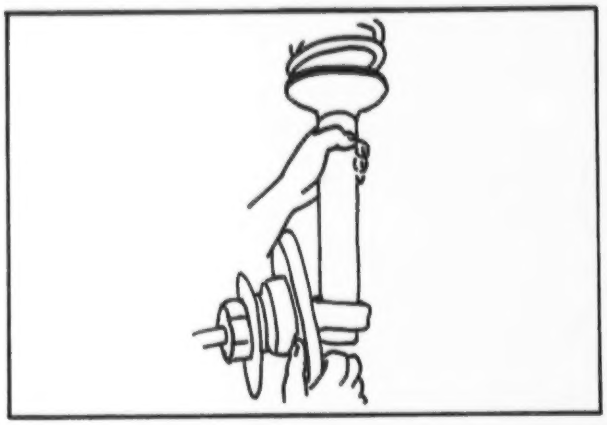


h. Remove the outer tie rod end. NOTE: This step is not necessary on all cars.



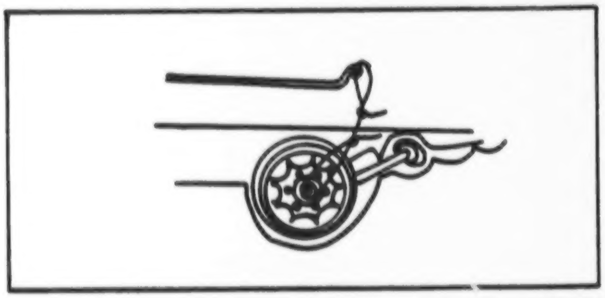


i. Loosen and remove the lower mounting bolts.

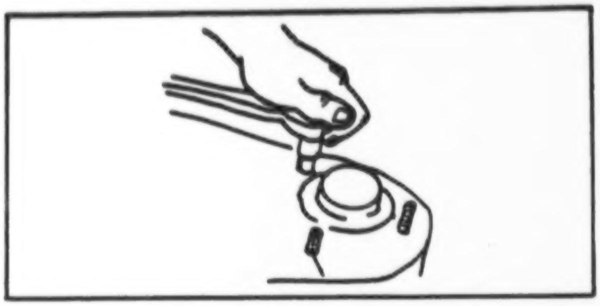


j. Separate the MacPherson strut from the steering knuckle.

k. With a piece of mechanics' wire, hang the steering knuckle so the axle shaft on front wheel drive cars is not damaged.



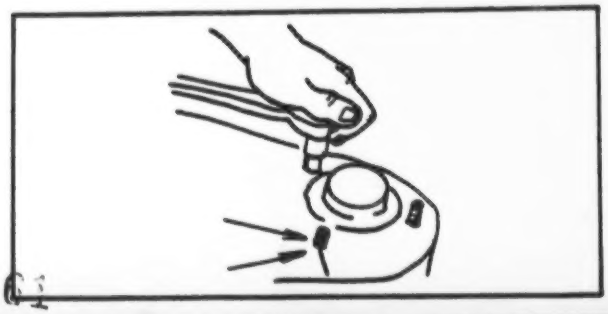
l. Remove the remaining bolt in the top mount and carefully lift out the MacPherson strut.



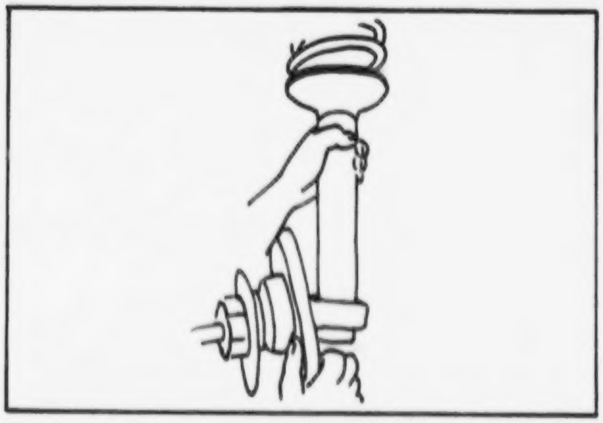
NOTE: On front wheel drive cars, be careful not to damage the boot on the axle shaft.

(Installation)

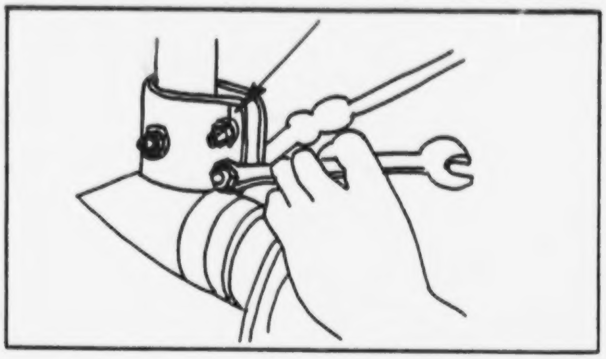
m. Carefully set the MacPherson strut in place and start one of the top mounting bolts. (NOTE: Put the marked stud in the marked hole so the assembly will be as it was originally.)



n. Join the MacPherson strut to the steering knuckle.

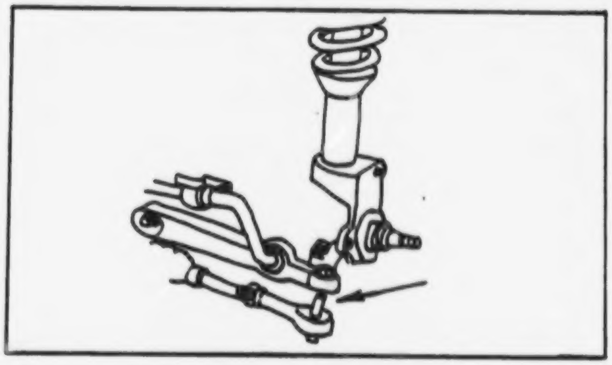


o. Install the lower mounting bolts. Once again, use your reference marks to put it in the exact original position. Torque the mounting bolts to specification.



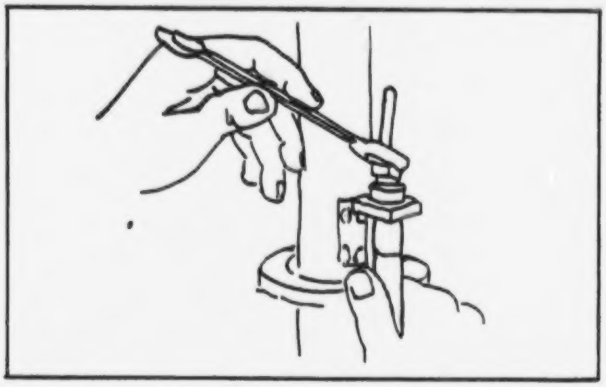
p. Reinstall the outer tie rod, torque the nut to specification and install a new cotter pin.

q. Reconnect the brake line and bleed the brakes.

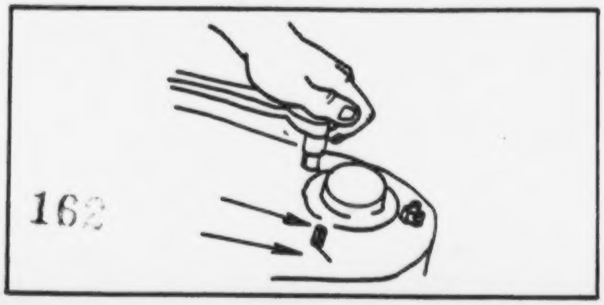


NOTE: Brake system service is not covered in this unit. See your instructor for more information.

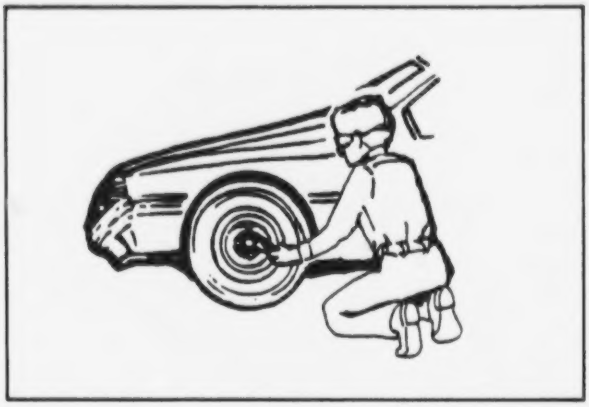
r. Replace the tire and lug bolts.



s. Install the two remaining nuts on the top mount and torque all three to specifications.

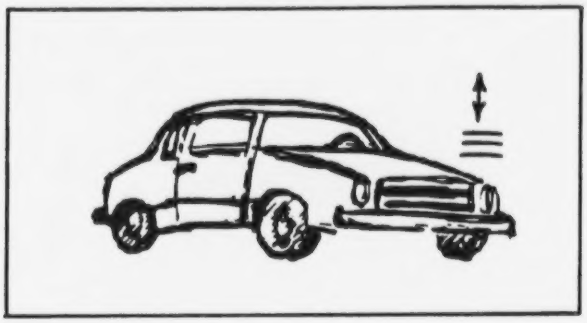


t. Lower the car to the ground.



u. Torque the lug nuts and install the wheel cover.

v. Bounce the car to make sure the MacPherson strut works freely.



x. Align the wheels at which the MacPherson struts were installed. NOTE: Wheel alignment is not covered in this unit. See your instructor for more information.

y. Put away your equipment and clean up the work area.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

REMOVING AND INSTALLING MACPHERSON STRUTS

SKILL SHEET 2

Directions: Before removing and installing a MacPherson strut, answer the following questions. If you are not sure of an answer, look back at the text for help.

1. The last mounting bolt removed is an (upper, lower) mounting bolt.
2. Locating marks may need to be placed on (the top, the bottom, both) ends of the MacPherson strut.
3. It is (okay, not okay) to let the steering knuckle hang free after the strut has been removed.
4. It (is, is not) necessary to torque the lug nuts, upper mounting bolts and lower mount when installing MacPherson struts.
5. If the hydraulic part of the brake system was open we (must, must not) bleed the system before the car can be driven.

REMOVING AND INSTALLING MACPHERSON STRUTS

ACTIVITY SHEET 2

1. See your instructor to get a car that needs to have its MacPherson strut removed and replaced.

    make of car __________
    year _____
    model __________

    Front _____ Rear _____ Both _____

2. Review the procedure outlined in this unit and the appropriate service manual for the car.

    NOTE: Service manuals may give you a specific procedure or method that will make the job less difficult.

3. Secure the tools, equipment and new MacPherson struts (make sure the new MacPherson struts are the correct type for the car).

4. Complete the service procedure **(Wear eye protection)**.

5. Bounce the car to make sure the MacPherson struts work freely.

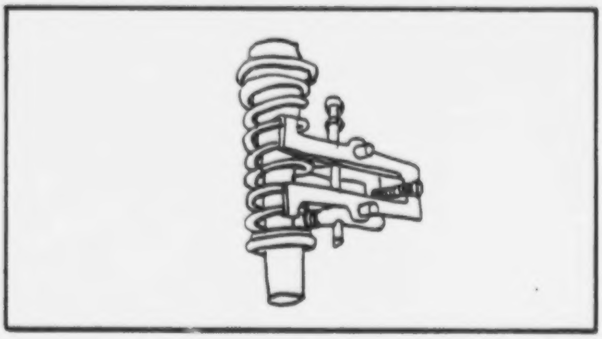
6. Put away the tools and equipment and clean up the work area.

2. Rebuilding MacPherson struts

You will need the following equipment:

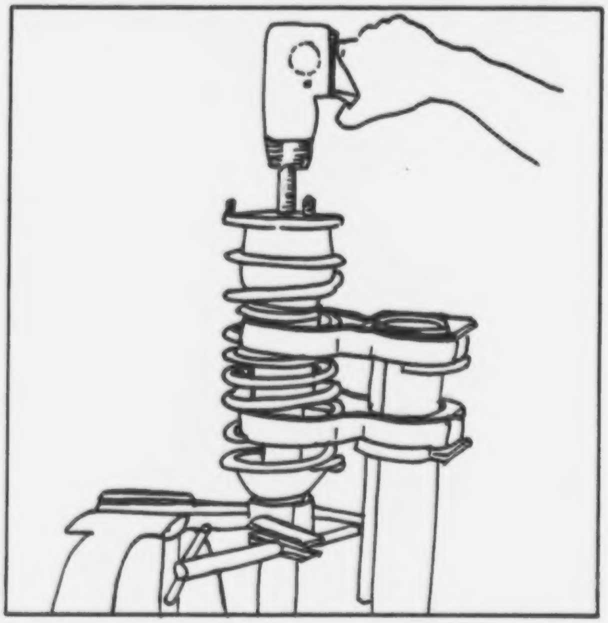
MacPherson strut spring compressor
Spanner wrench
Torque wrench
Hand tools
Strut clamp
Vise
Measuring cup

Always wear safety glasses.



(Disassembly)

a. Remove the MacPherson struts from the car. (NOTE: The procedure is outlined in this unit.)

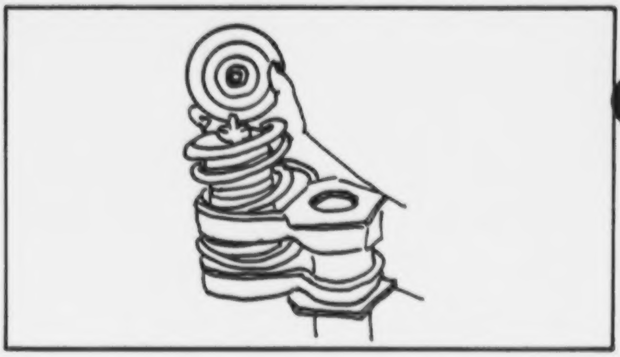


b. Mount the MacPherson strut assembly in a strut clamp. (NOTE: Strut clamp must be bolted to a bench or secured in a vise.)

c. Install the spring compressor and compress the spring. (NOTE: Follow the procedure that comes with the spring compressor. If you need help, ask your instructor.)

d. Remove the center retaining nut from the top mount assembly.

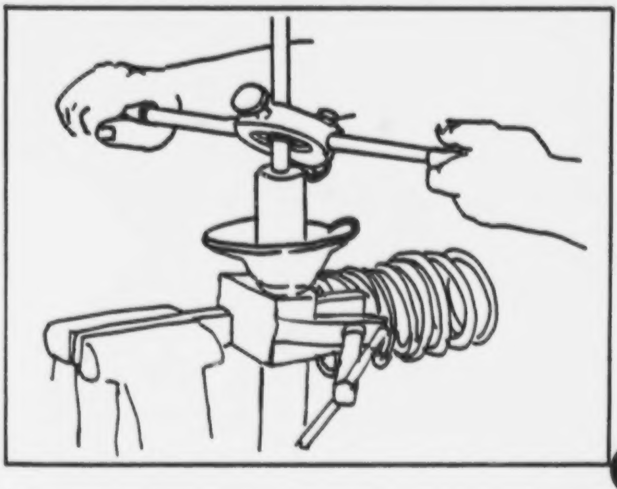
e. Lift off the top mount and spring. (NOTE: If the MacPherson strut is nonserviceable, go back to step "m," on page 39.)



(Cartridge replacement)

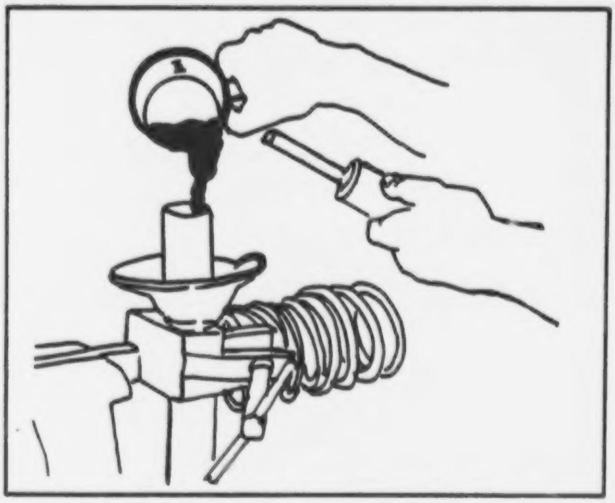
f. Use the spanner wrench to remove the large nut from the strut tube. (NOTE: On some strut tubes, the top has to be cut off.)

g. Remove the old cartridge and pour oil in the strut tube to the measuring cup.



h. Clean out the strut tube and threads.

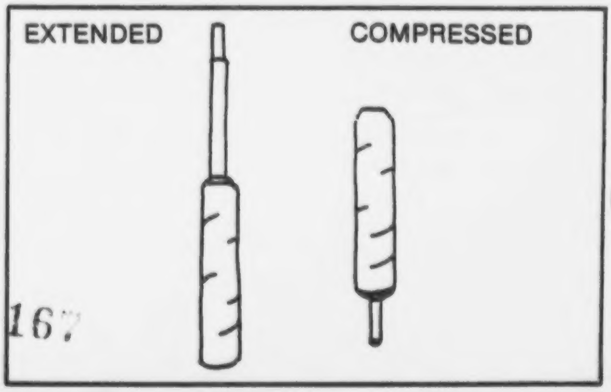
i. Install a new cartridge and fill the strut tube with the correct amount of oil. (NOTE: The oil level specification should be in the new MacPherson strut's box.)



j. Purge the new strut cartridge and install it.

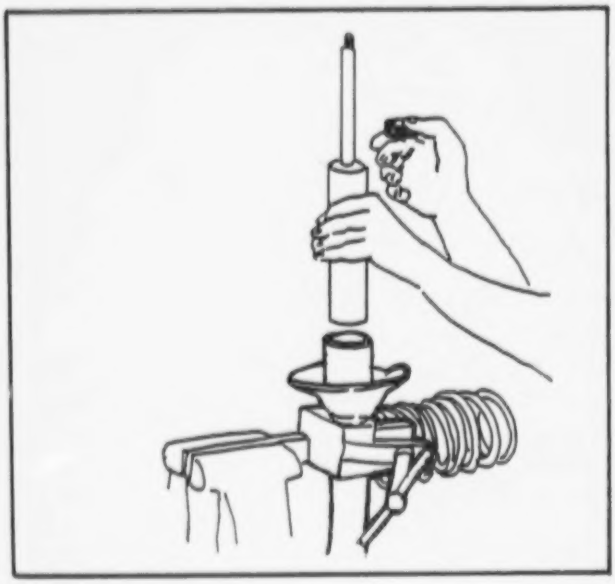
- Turn the strut cartridge right side up and extend it to maximum length.

- Turn the strut cartridge upside down and compress it to minimum length.



k. Install the spacers and center retaining nut. (NOTE: Follow the procedure that comes with the new strut cartridge.)

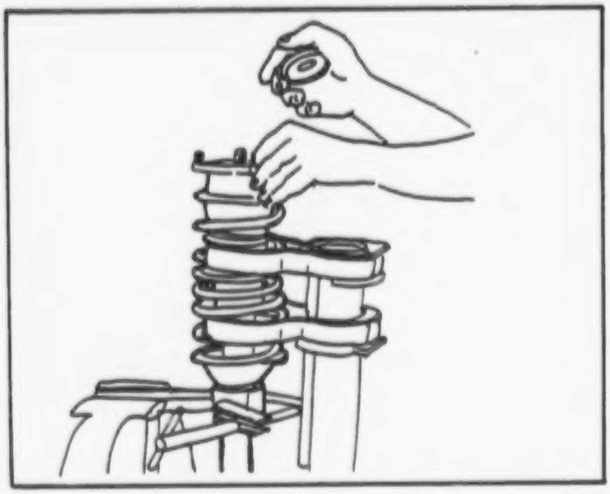
l. Tighten the spanner nut to specification.



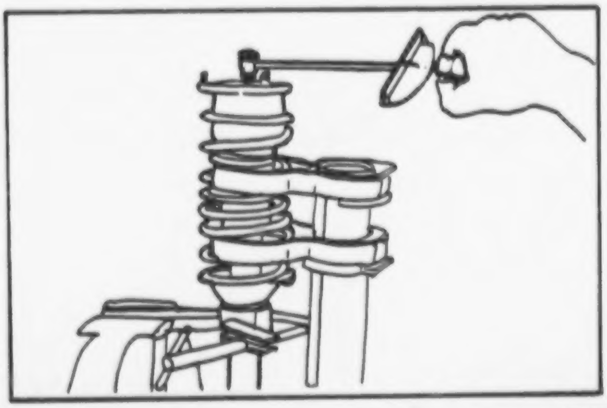
(Assembly)

m. Install the spring. (NOTE: Make sure the spring is positioned against the lower spring seat.)

n. Install the top mount. (NOTE: Make sure the spring is positioned against the top spring seat.)

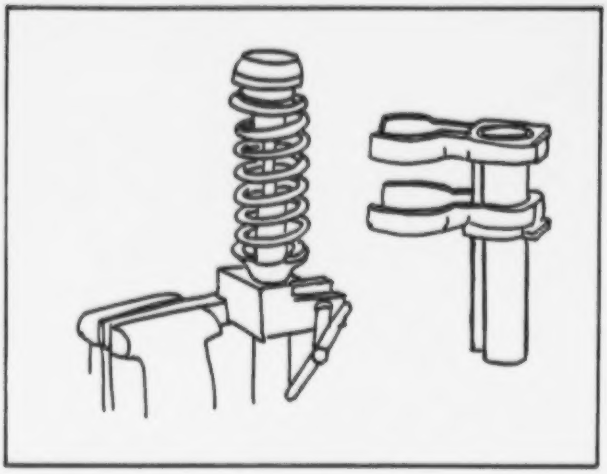


o. Install a new center retaining nut and torque it to specification. (NOTE: Check to make sure the upper mount is not binding.)

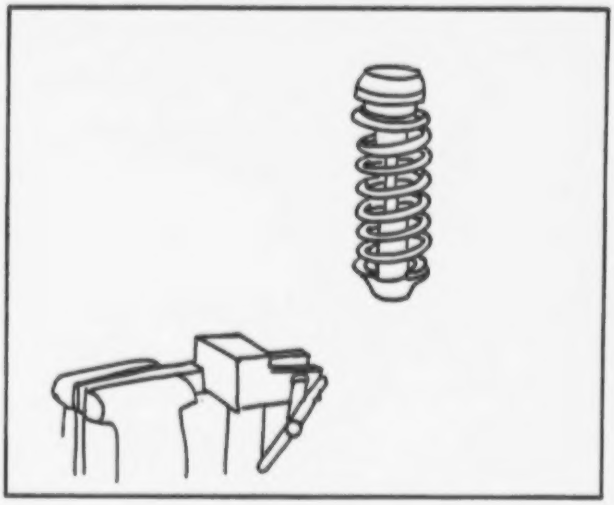


p. Remove the spring compressor.

q. Remove the MacPherson strut from the strut clamp.



r. Reinstall the MacPherson strut. (NOTE: Procedure is outlined in this unit.)



DO SKILL SHEET 3

DO ACTIVITY SHEET 3

REBUILDING MACPHERSON STRUTS

SKILL SHEET 3

Directions: Before rebuilding a MacPherson strut, answer the following questions. If you are unsure of an answer, look back at the text to find it.

1. The MacPherson strut (should, should not) be mounted in a special strut clamp.
2. Always remove the center retaining nut (before, after) the spring compressor is installed.
3. The spanner nut (does, does not) require a special wrench to remove and replace it.
4. It (is, is not) important to locate the spring in the upper and lower spring seats.
5. The old center retaining nut (should, should not) be reused.

REBUILDING MACPHERSON STRUTS

ACTIVITY SHEET 3

1. See your instructor to get a car that needs to have a MacPherson strut removed and replaced.

   make of car __________
   year _____
   model ___________

   Front _____ Rear _____ Both _____

2. Review the procedure outlined in this unit and the appropriate service manual for the car.

   NOTE: Service manuals may give you a specific procedure or method that will make the job easier.

3. Secure the tools, equipment, new strut cartridge and nut (make sure the new MacPherson struts are the proper type for the car).

4. Complete the service procedure **(Wear eye protection)**.

5. Confirm that the MacPherson strut works freely.

6. Put away your tools and equipment and clean up the work area.

CHECKING AND REPAIRING MACPHERSON STRUTS

UNIT REVIEW

1. A MacPherson strut combines the strut housing, shock absorber, coil spring and upper mount into a single unit.

   a. True b. False

2. Only remove the center retainer nut on a MacPherson strut after the coil spring has been safely compressed.

   a. True b. False

3. Always mark the upper and lower mount of a MacPherson strut before you take it apart so you will know how to put it back together.

   a. True b. False

4. Compared to other suspension systems, the MacPherson strut suspension system

   a. has fewer components.
   b. takes up less space.
   c. spreads the suspension load over a wider area of the car body.
   d. all of the above.

5. A shock cartridge in the MacPherson strut should last

   a. 2,000 to 5,000 miles
   b. 15,000 to 50,000 miles
   c. 80,000 to 100,000 miles
   d. seven to ten years

CHECKING AND REPAIRING MACPHERSON STRUTS

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Gathered necessary tools and equipment			
2. Put on his or her safety glasses			
3. Described the function of a MacPherson strut			
4. Inspected and tested MacPherson struts			
5. Replaced MacPherson struts			
6. Serviced MacPherson struts			
7. Cleaned the work area and put away tools			

Satisfactory - should move on ☐

Should repeat this unit ☐

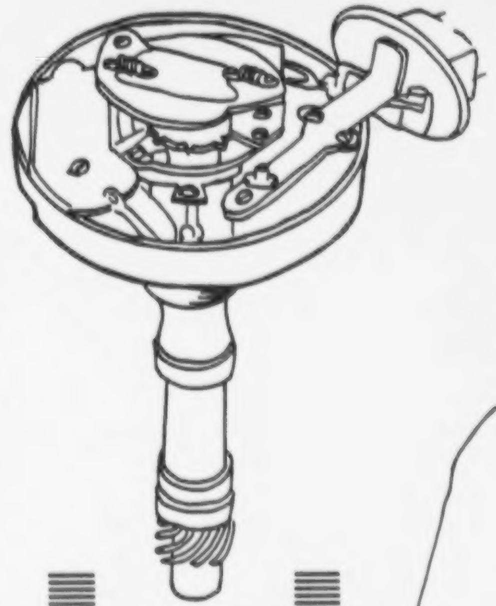
______________________ Student's Signature/Date

______________________ Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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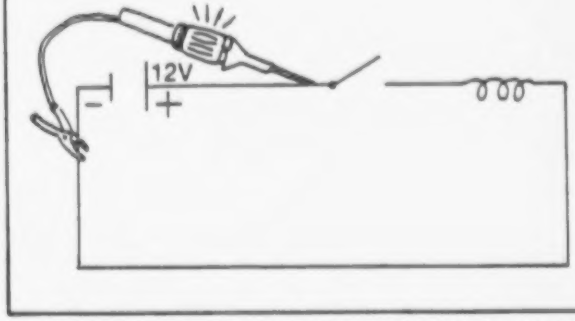

Unit 7

Using Meters to Test Wiring and Switches

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USING METERS TO TEST WIRING AND SWITCHES

INTRODUCTION

Often you need to use test equipment when diagnosing problems with a car. In fact, test equipment and wiring diagrams are your best tools for correcting a car's electrical problems. In this unit, you will learn how to use common test equipment.

UNIT OBJECTIVE

After completing this unit, you will be able to use various tools to check and repair electrical systems.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to specifically:

1. Choose the right equipment to test a problem in an electrical system.
2. Use jumper wires and a 12-volt test light to find problems in circuits.
3. Measure circuit resistance.
4. Locate grounds and breaks in circuits.
5. Measure voltage.
6. Read scales on meters (analog and digital).
7. Measure amperage in circuits.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

1. **Ammeter** - an instrument used to measure rate of current flow (in amperes).

2. **Circuit** - a complete or partial path through which current flows.

3. **Fuse** - a protective device that breaks the flow of current when the current draw exceeds the capacity of the fuse.

4. **Jumper wires** - a multi-strand piece of wire, with alligator clips on its ends, used to jump or bypass sections of a circuit.

5. **Multimeter** - a device that combines two or more meters in one. The most common multimeter is a Volt/Ohm Meter (VOM).

6. **Ohmmeter** - an instrument used to measure the amount of resistance in a circuit (in ohms) and to find open circuits and grounded circuits.

7. **Relay** - a magnetically operated switch used to make and break the flow of current in a circuit.

8. **Switch** - a device for making, breaking or changing the connections in an electrical circuit.

9. **Systematic** - a step-by-step, thorough plan or procedure.

10. **12-volt test light** - a three-part instrument (ground clip, probe and light) used to find a break in a circuit by testing for the presence of voltage.

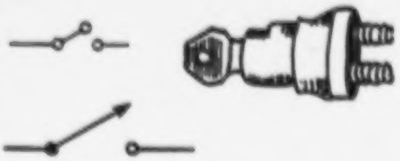
11. **Voltmeter** - an instrument used to measure pressure in a circuit (in volts).

12. **Wiring** - strands of copper covered with plastic shielding.

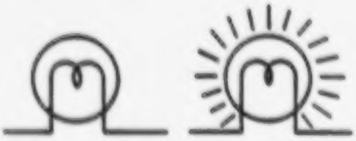
13. **Wiring diagram** - a drawing that shows various electrical units and the wiring arrangements necessary for them to function properly.

Equipment

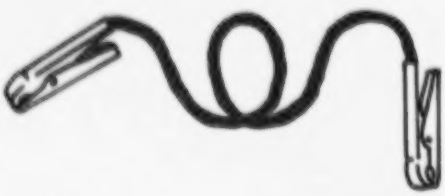
Switches



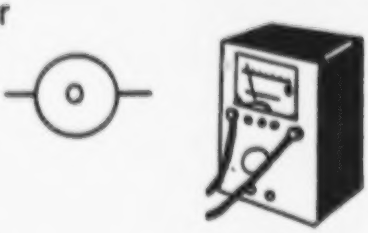
Lights



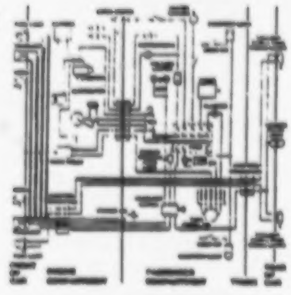
Jumper wires



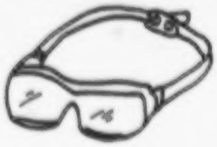
Ohmmeter



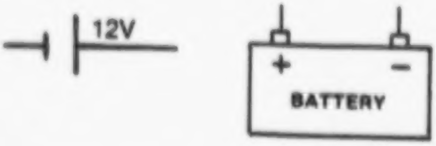
Wiring diagrams



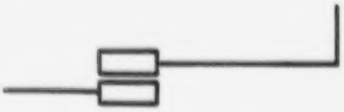
Safety glasses



Battery

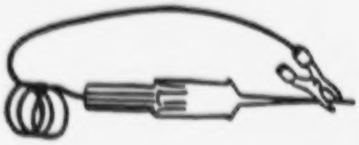


Relay

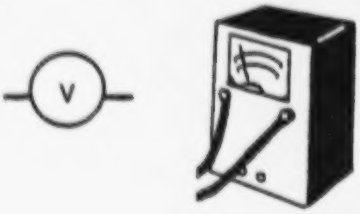


Wiring

12-volt test light

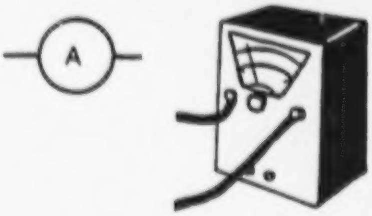


Voltmeter



Specifications manual

Ammeter



B. Introduction to circuits

Electrical devices can be put into many complex circuits, each serving some specific purpose.

Circuits are a system of electrical components that form a path for electrical current.

To work properly, the circuit must be unbroken and should be shaped somewhat like a circle. There can be no holes in a circuit. Otherwise, the current cannot go through, and a short occurs.

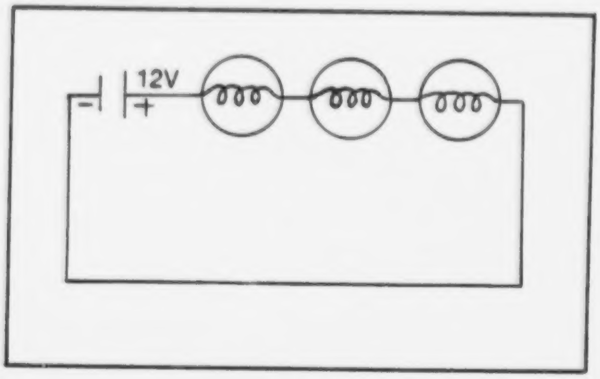
The electrical technician must know how the circuit has been arranged before it can be tested and repaired.

There are three main types of circuits:

(1) **series circuits,**
(2) **parallel circuits** and
(3) **series-parallel circuits.**

1. Series circuit

In the series circuit, the components of the circuit are placed end to end in a "series." The parts are lined up one by one.

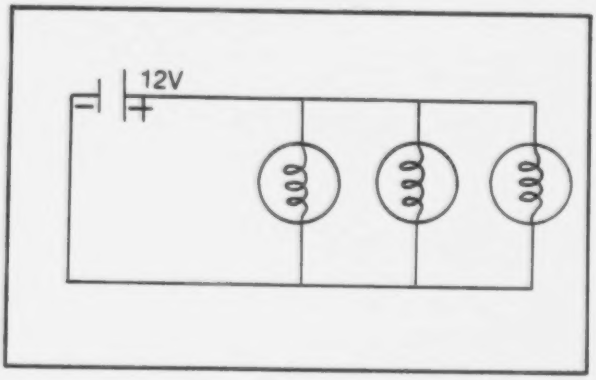


a. In a series circuit, each component gets electrical current from the component that comes before it in line.

b. If any component in the circuit fails and stops the current flow, all components in the circuit will not get current.

2. **Parallel circuits**

In a parallel circuit, all positive connections of the circuit components are hooked to a common point and all negative connections of the components are hooked to a common negative.



a. Each component in a parallel circuit operates independently from the others in the circuit.

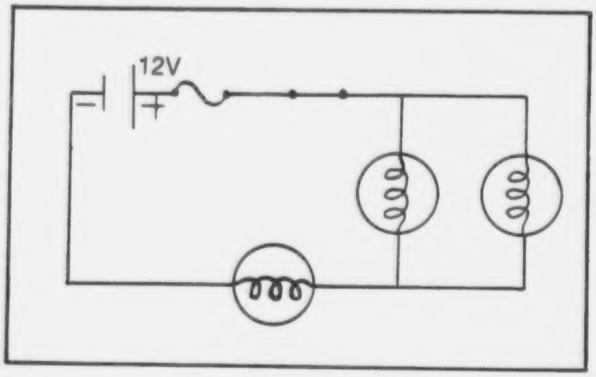
In a parallel circuit, current does not have to flow through one component to get to the next. Instead, the current can choose which path it will take.

b. In a parallel circuit, each component gets equal access to the available current.

c. The failure of any component in a parallel circuit has no effect upon other components. The current simply takes another path.

3. Series-parallel circuits

A series-parallel circuit is a mixture of the two previous types of circuits. The series-parallel circuit has some components arranged in series and some in parallel.



a. Each component of the circuit functions according to its location in the circuit.

REMEMBER: The main difference between a series and parallel circuit is in current flow.

When components are placed in a series, current must pass through one component before it gets to another.

When components are placed in a parallel formation, current can choose its travel path. The current does not have to go through all the components.

DO SKILL SHEET 1

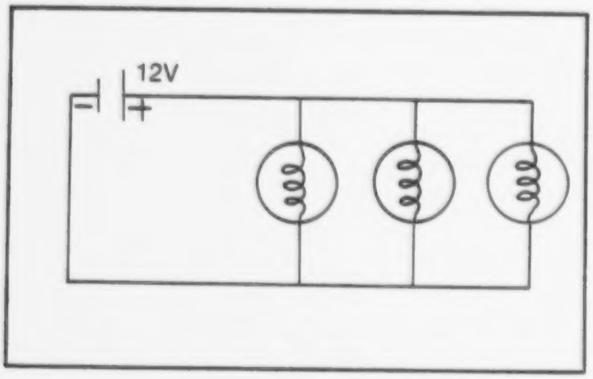
181

SKILL SHEET 1

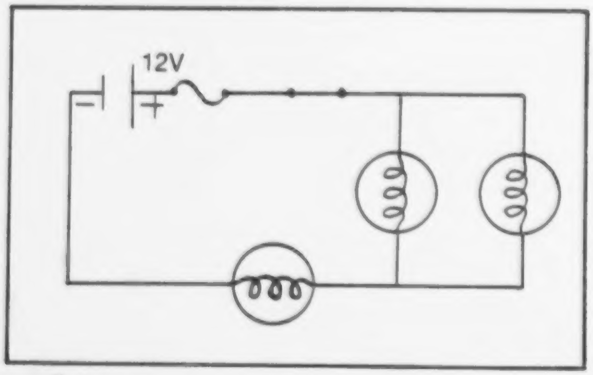
Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

series
series-parallel
parallel

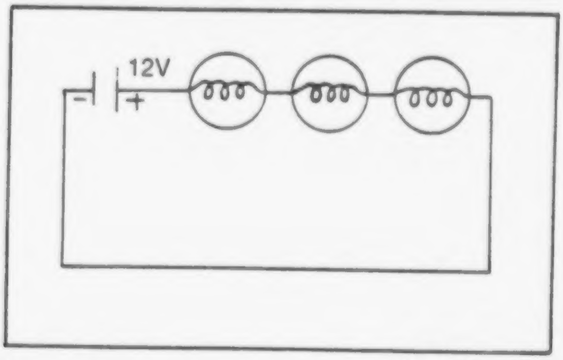
1. This is an example of a ______________________ circuit.



2. This is an example of a ______________________ circuit.



3. This is an example of a ______________________ circuit.

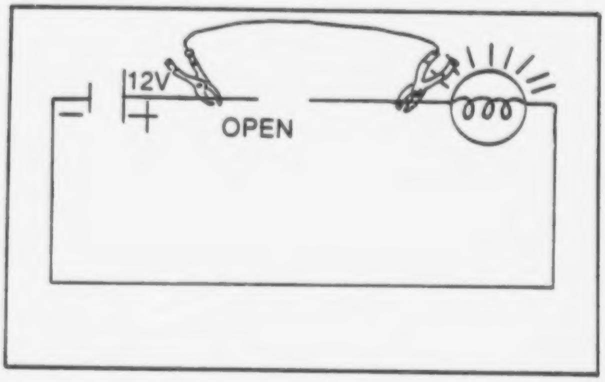


4. If any component fails in a ______________________ circuit, the whole circuit will not get current.

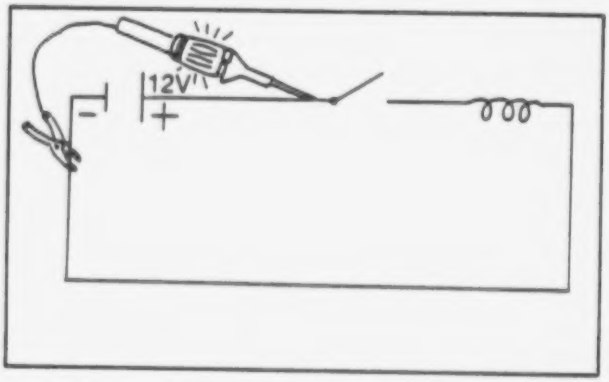
5. If any component fails in a ______________________ circuit, all other pathways still get current.

C. Test equipment

The electrical specialist uses a wide variety of test instruments to measure electrical activities within a circuit.



1. **Jumper wires** are used to bypass the portion of the circuit that might be bad.



2. **Test lights** are used to locate voltage in a particular spot in the circuit. If voltage is present, the light goes on.

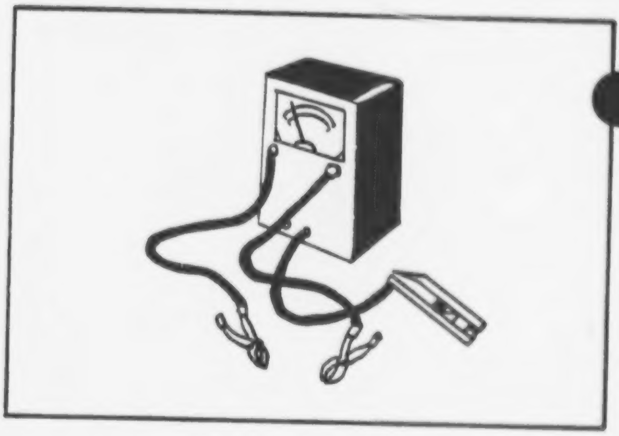
   (A test light and a voltmeter are used in much the same way.)

3. **Meters** are designed to measure a circuit's voltage, current and resistance. From the test results, a technician can tell how well the circuit works.

   There are two styles of meters, (1)analog and (2)digital.

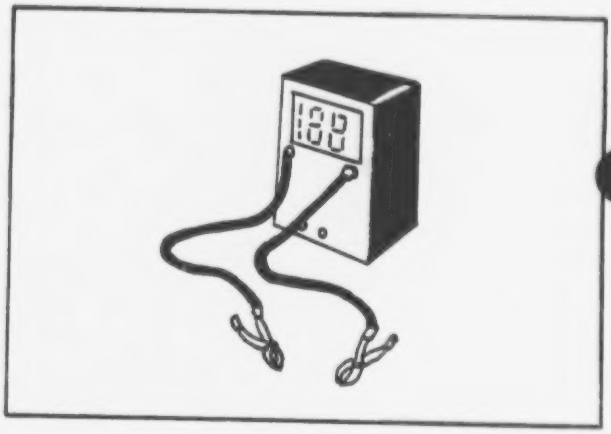
a. The analog meter has a dial and a hand that sweeps across a scale to measure voltage.

The meter measures voltage, current and resistance with the same needle, using a different scale. The meter is hooked to the circuit in a different way when measuring each of these three electrical qualities.



b. The digital meter is a solid state instrument that gives a numerical (in numbers) reading on the meter's face.

Once again, readings for voltage, current and resistance show up on the face of the meter. You just have to hook the meter to the circuit in a different way for each of the three measurements.

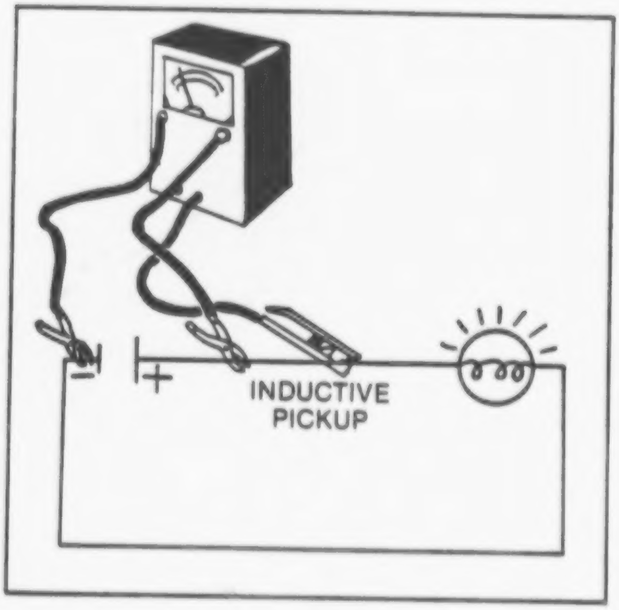


4. An ammeter measures current flow in a circuit.

It comes in two styles:
(1)Inductive pick-up style and
(2)Shunt style.

185

a. If the meter is equipped with an inductive pick-up, the meter's operation is different for the measurement of electric current (Amps).



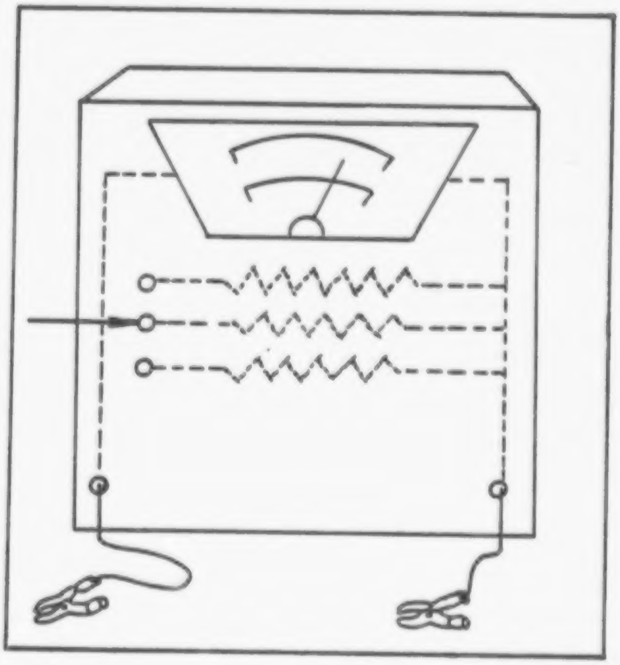
Some (not all) digital ammeters and some (not all) analog ammeters use an inductive pick-up to measure current. If the meter you use has an inductive pick-up, you clamp the pick-up around a wire in the circuit you are going to test.

Make sure you hook the positive lead to the positive post on the battery. The negative lead hooks to the negative post.

b. The shunt style uses an analog meter arrangement and shunt resistors to vary the range of the meter for different levels of current flow.

Resistors (shunts) of different sizes are hooked in parallel to the meter, causing more or less current to pass through the meter coil.

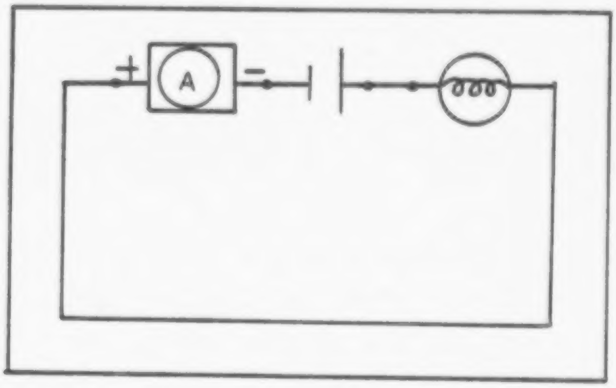
- On most ammeters, the shunt is built into the meter and the technician can change the range by adjusting the knob or switch on the meter.



- To measure current flow in a circuit, the meter and shunt must be hooked to the circuit in series.

  When the meter is hooked in series with the circuit, all the current flowing in the circuit does not pass through the meter.

  The rate of flow through the circuit will move the coil in relation to the rate of current flow.



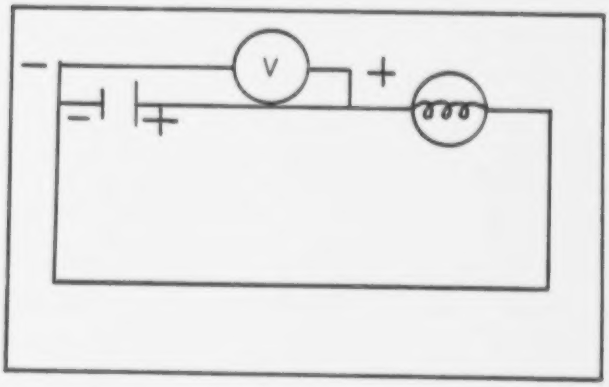
(CAUTION: To avoid severely damaging the meter, be sure it can handle the expected current and is connected in series with the circuit.)

5. The **voltmeter** is an analog meter that measures the electron force (voltage) in a circuit.

a. The voltmeter is similar to the ammeter. However, its resistors are arranged differently.

b. Also, the voltmeter is hooked to the circuit differently when taking measurements.

Voltmeters are hooked up parallel to the circuit. The rate of current flow through the voltmeter is determined by how much electrical force (voltage) is in the circuit.



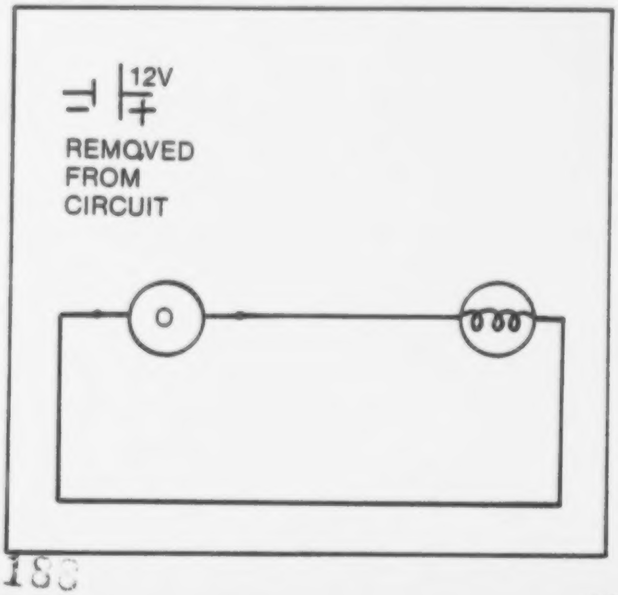
6. The **ohmmeter** is an analog meter that measures the electrical resistance in a circuit or the circuit's components.

The ohmmeter registers readings in much the same way as the ammeter and voltmeter.

However, the ohmmeter contains its own power supply.

(CAUTION: Be sure there is no power in the circuit before hooking up the ohmmeter.)

a. After removing power from the circuit, substitute a known force (voltage) for the power.



183

By measuring the rate of current flow through the circuit, the resistance of the circuit can be determined because voltage, current and resistance are related.

b. To vary the range of the ohmmeter, resistors are placed in series with the meter and the meter's power supply.

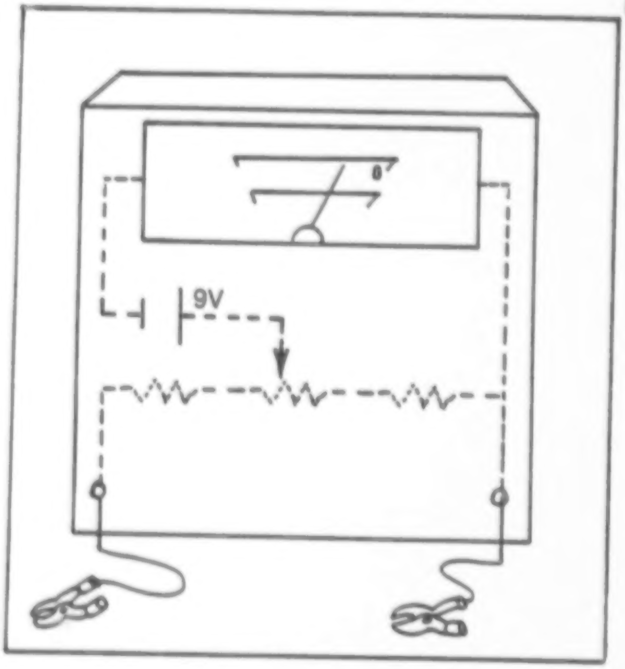
Adding resistors means more resistance and less voltage coming to the meter. This results in a lower reading.

c. On most ohmmeters, the resistors are built into the meter.

The technician can change the range by adjusting the knob or switch on the meter.

d. To assure an accurate ohm reading, the meter must be set to zero.

To "zero" the meter, connect the two meter leads together and adjust the knob.



7. A **multimeter** combines a multirange ammeter, a multirange voltmeter and a multirange ohmmeter in a single instrument.

   Expensive multimeters tend to be more expensive because they have more functions and ranges.

DO SKILL SHEET 2

SKILL SHEET 2

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

jumper wire
test light
analog
digital

ammeter
ohmmeter
voltmeter
multimeter

1. The ______________ sometimes uses a shunt.

2. Never hook a _____________ to a live circuit.

3. The ______________ style of meter uses a needle and scale.

4. Always hook _______________ in parallel to the circuit.

5. The ______________ must be set to zero before using it.

C. Procedure for using jumper wires

Jumper wires are used when trying to find a broken circuit. Let's say we have a problem. A light in the car is not working.

1. Turn on one or more load devices (lights or motors) on the car to make sure the battery is not dead. If nothing on the car works, test the battery.

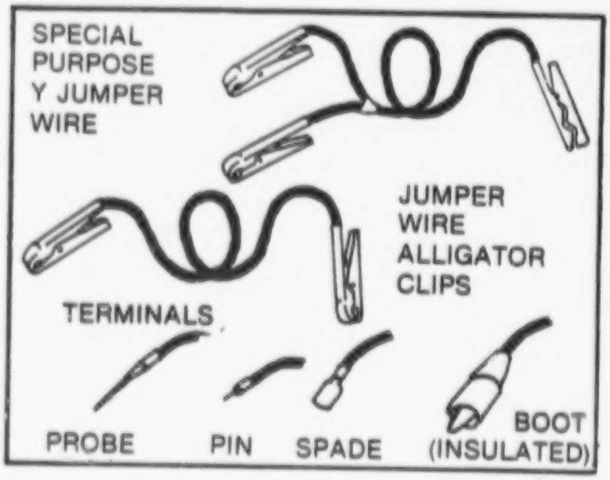
(NOTE: Battery testing is not covered in this unit. See your instructor for details.)

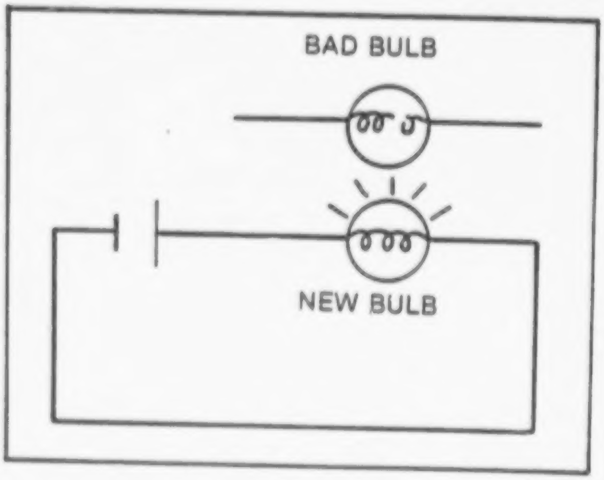
2. If other electrical devices on the car work, try replacing the bulb with a new bulb.

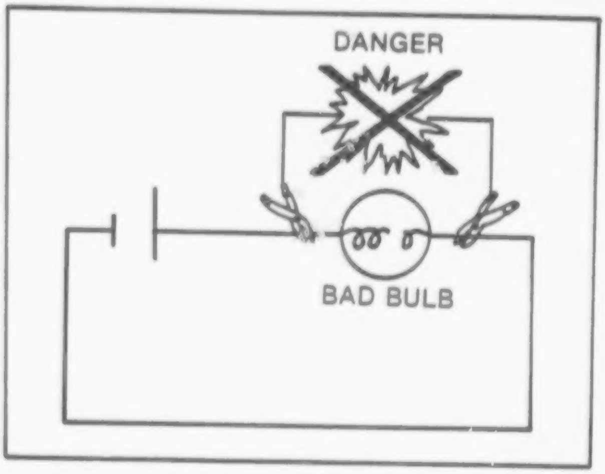
   If the circuit still does not work, use a jumper wire to test the positive side, and then the negative side of the circuit.

3. Jumper wires are used to bypass or jump sections of a circuit.

a. Never substitute a jumper wire in place of the load device in the circuit.

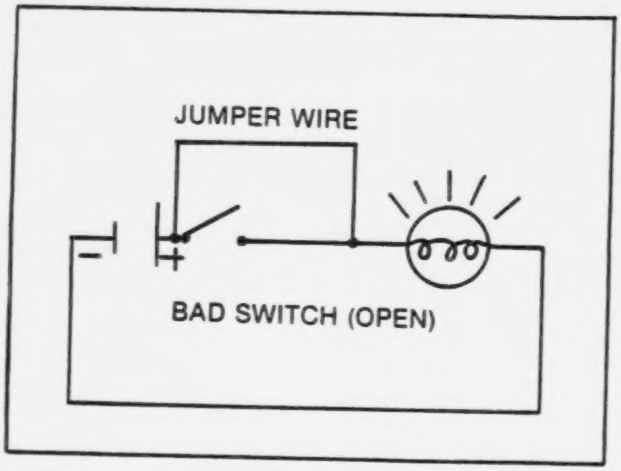

SPECIAL PURPOSE Y JUMPER WIRE
JUMPER WIRE ALLIGATOR CLIPS
TERMINALS
PROBE
PIN
SPADE
BOOT (INSULATED)


BAD BULB
NEW BULB


DANGER
BAD BULB

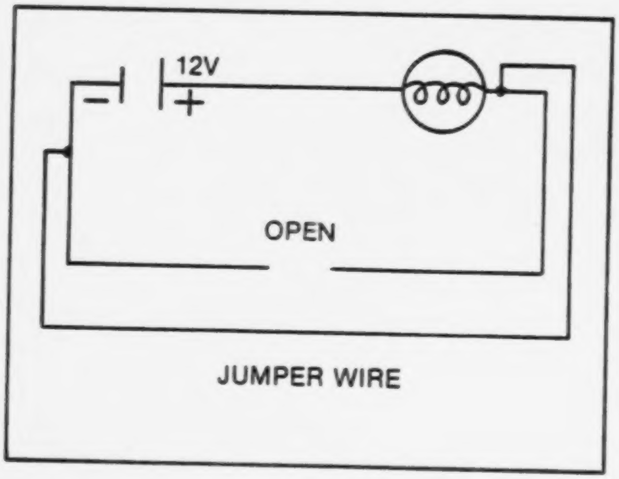
b. If a lamp doesn't work, check the positive side of the circuit by hooking a jumper wire from the "positive" pole on the battery to the "positive" pole on the lamp.

- If the lamp works when hooked directly to the battery's positive post, the circuit's positive side has a break in it.



- If the lamp does not work when hooked directly to the battery's positive post, the lamp, ground circuit or jumper wire is not working properly.

d. If the lamp does not work after testing the positive side of the circuit, check the negative side of the circuit by hooking a jumper wire from the Lamp's negative pole (ground) to the battery's negative pole (ground).



- If the lamp works when hooked directly to the battery's negative post, the circuit has a break in the negative (ground) circuit.

- If the lamp does not work when hooked directly to the battery's negative post, the lamp or the jumper wire is not working properly.

DO SKILL SHEET 3

DO ACTIVITY SHEET 1

SKILL SHEET 3

Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

open
negative
load device
positive
power
short
battery

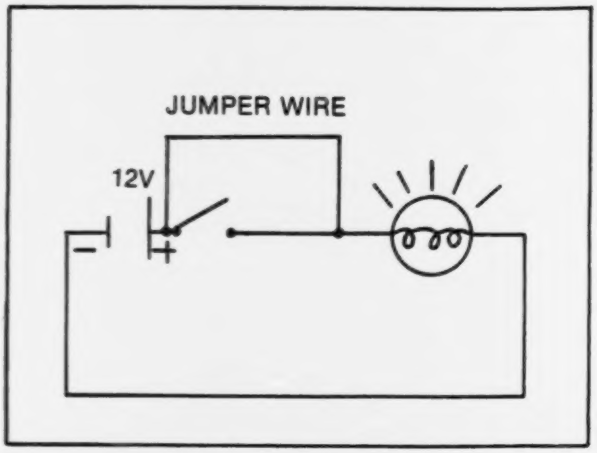
1. Before starting the jumper wire test, always make sure the ____________________ is charged.

2. Never use a jumper wire in place of a ____________.

3. Jumper wires are most often used to find ___________ circuit failures.

4. If a lamp works when the jumper wire is hooked between the battery negative and the load device ground, the problem is in the _______ ________________ circuit.

5. This is an example of using a jumper wire to test the ________ circuit.



TESTING A CIRCUIT WITH JUMPER WIRE

ACTIVITY SHEET 1

1. See your instructor to get a car that needs a circuit tested with the jumper wire method.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed. WEAR EYE PROTECTION!

4. Turn on one or more load devices to make sure the battery is not dead. If it is O.K., procede to step five. If not, test and recharge the battery. Then repeat step four.

5. Check the condition of the load device. If the device is O.K., go to step six. If not, replace the load device. If the circuit still does not work, proceed to step six.

6. Use jumper wire to bypass the positive section of the circuit. Record your results:

____

____

____

____

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7. Use jumper wire to bypass the negative section of the circuit. Record your results:

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8. Record what is wrong with the circuit and discuss with your instructor what steps to take to repair the problem.

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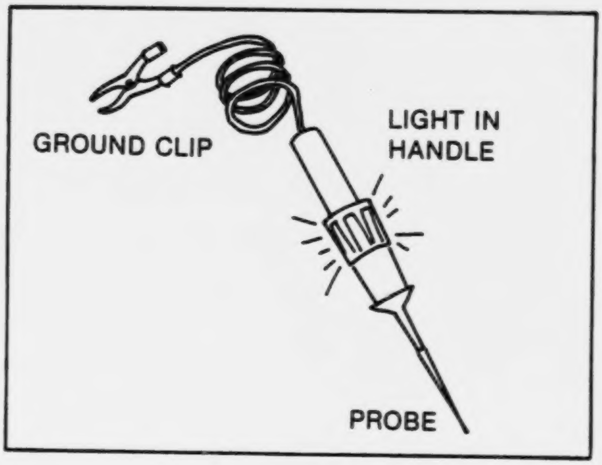
____

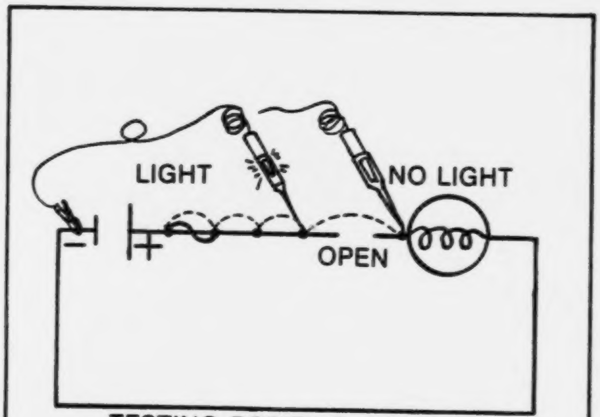
9. Put away your tools and clean up the work area.

D. Procedure for using a 12-volt test light



1. Like the jumper wire, the test light is used to isolate breaks in a circuit. The difference between the two testers is that a jumper wire bypasses the circuit entirely, while the test light finds the precise location of the break.

2. The test light tells you if a complete circuit exists by locating the presence of voltage.

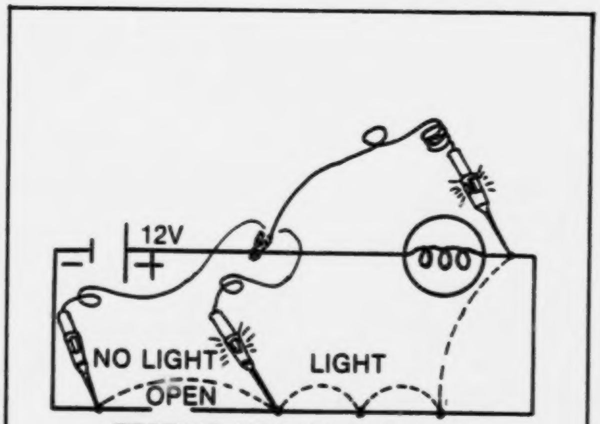


TESTING POSITIVE CIRCUIT

3. Clip the test light's ground clip to a ground and touch some point in the circuit with the probe.

- If voltage is present, the light will light up. This means the circuit is complete up to the point the probe is touching.

- If the light stays off, there is a break somewhere between the probe and the last point tested. You must then move the probe back and forth along the circuit until you find the break.



TESTING NEGATIVE CIRCUIT

DO SKILL SHEET 4

DO ACTIVITY SHEET 2

SKILL SHEET 4

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

breaks
negative
on
positive
grounds
off
testlight
open

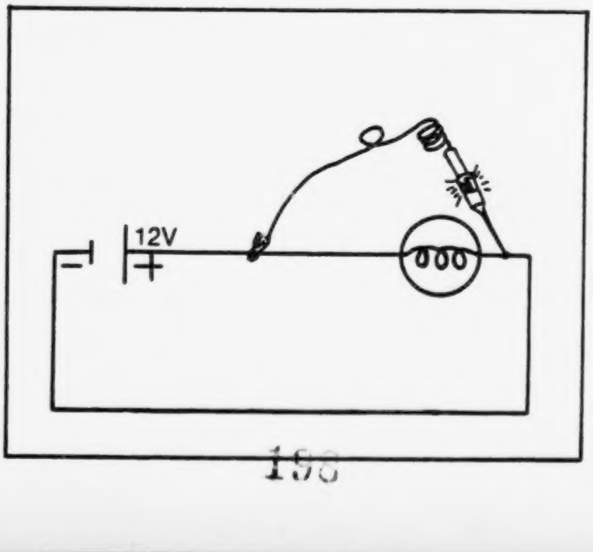
1. One advantage of using a test light over a jumper is that the test light can find the exact location of the ______________ in the circuit.

2. To test the positive side of the circuit, attach the clip end of the test light to the ________________ post of the battery.

3. Test lights are used to locate _______________ circuits.

4. If the circuit is O.K. up to the location you are testing, the light will stay ____________________________ when the wire is probed.

5. The picture below shows a test light being used to check the ________ ______________________________ circuit.



TESTING A CIRCUIT WITH A 12-VOLT TEST LIGHT

ACTIVITY SHEET 2

1. See your instructor to get a car that needs a circuit tested using a 12-volt test light.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed. WEAR EYE PROTECTION!

4. Test the positive section of the circuit by clipping one end of the test light to a good ground and touching several points in the positive section of the circuit. Record your results:

5. Test the negative section of a circuit by clipping one end of the test light to a good ground and touching several points in the negative section of a circuit. Record your results:

6. Record what is wrong with the circuit and discuss with your instructor steps to repair the problem.

7. Put away your tools and clean up the work area.

E. Procedure for using an Ohmmeter

1. When using an Ohmmeter to measure resistance, there are four basic steps:

    a. Isolate the resistance from power.

    b. Zero the ohmmeter.

    c. Connect the meter leads across (to both ends of) the resistance.

    d. Read the scale on the meter labelled "actual ohms."

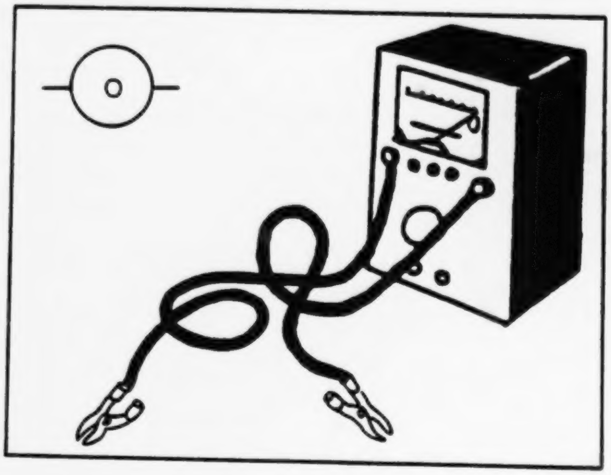
2. When using an Ohmmeter to check for grounds and open circuits, there are four basic steps:

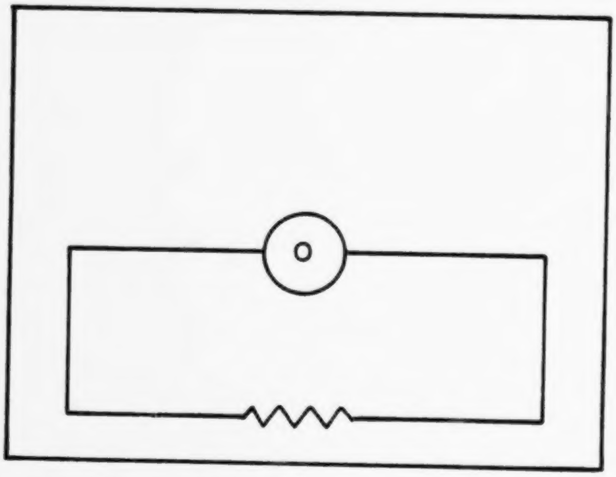
    a. Isolate the circuit from power and ground.

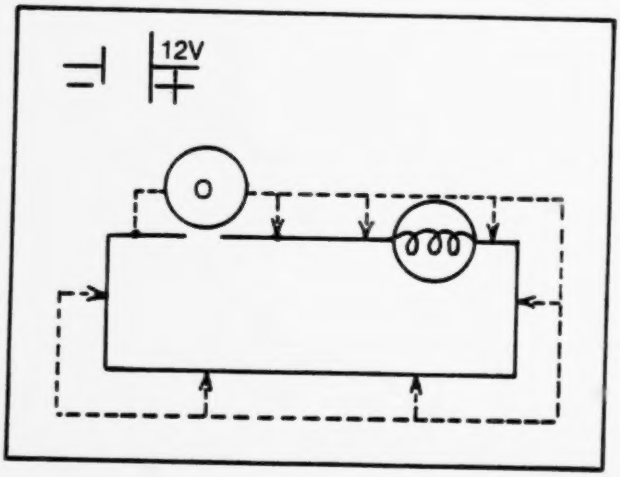
    b. Zero the ohmmeter.

    c. Connect one ohmmeter lead to a ground.

    d. Start at either end of the isolated circuit, slowly inching along to probe segments of the circuit.







- If resistance is "infinite," (resistance is as high as possible) something has stopped the current from coming through, and there is no link to the ground.

- If resistance is "zero," (there is no resistance) a "dead short" to ground has occurred. In this case, the ground and circuit are probably in direct contact.

DO SKILL SHEET 5

DO ACTIVITY SHEET 3

SKILL SHEET 5

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

high
ohmmeter
infinite
resistance
battery
low
zero
load

1. The ohmmeter is used to check for ______________ in the circuit.

2. Always remove the ______________ before testing a circuit.

3. To ensure accuracy of your readings, always ______________ the ohmmeter first.

4. If the resistance is excessively high, you will get a __________ reading on the meter.

5. A low reading on the meter means the circuit resistance is ________ _________________________ .

MEASURING RESISTANCE WITH AN OHMMETER

ACTIVITY SHEET 3

1. See your instructor to get a car that needs the resistance in a circuit measured.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed. WEAR EYE PROTECTION!

4. Complete the procedure using an analog ohmmeter. Record your results.

____

____

____

____

____

5. Repeat the procedure using a digital ohmmeter. Record your results.

____

____

____

____

____

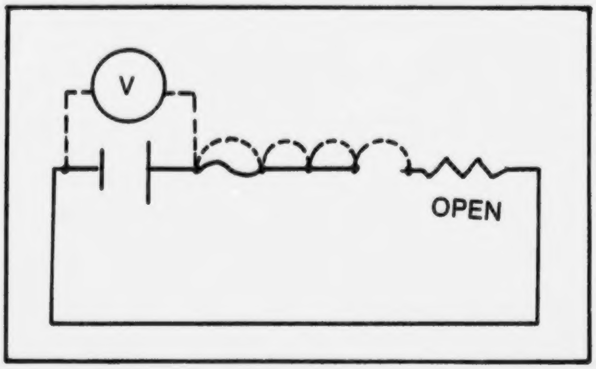
6. Explain why you did or did not get the same reading as was obtained in step four and step six.

7. Record what is wrong with the circuit and discuss with your instructor steps to repair the problem.

8. Put away your tools and clean up the work area.

F. Procedure for using a Voltmeter

A voltmeter has two leads -- one positive and one negative. Voltmeters are always hooked into a circuit in parallel.



1. Adjust the voltmeter to the correct range.

2. Reading battery voltage:

   a. Hook the meter up, making sure to hook the positive lead to the positive battery post and the negative lead to the negative battery post.

   b. Read the battery voltage from the scale on the meter.

3. Reading Circuit Voltage

   a. Adjust the voltmeter to the correct range.

   b. Hook the meter up, making sure to hook the negative lead to the negative battery post.

c. With the positive lead probe segments of the circuit, try to isolate the "open," or location of high resistance.

DO SKILL SHEET 6

DO ACTIVITY SHEET 4

SKILL SHEET 6

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

battery
series with
open
range
positive
short
parallel to
negative

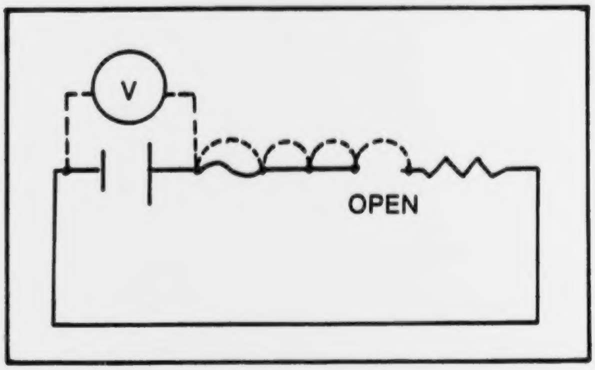
1. Voltmeters are used to locate a(n) ____________ circuit.

2. When testing the battery, the positive lead of the voltmeter connects to the __________________________________ post of the battery.

3. Always connect the voltmeter in ______________ the circuit to be tested.

4. Before connecting the voltmeter to the circuit, make sure the voltmeter ______________________________ is correct.

5. The drawing below is an example of using a voltmeter to test the __________________________ circuit.



MEASURING VOLTAGE WITH A VOLTMETER

ACTIVITY SHEET 4

1. See your instructor to get a car that needs the voltage in the battery and circuit tested.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed. WEAR SAFETY GLASSES!

4. Measure the battery voltage using an analog meter. Record your results.

____

____

____

5. Repeat the procedure using a digital meter. Record your results.

____

____

____

6. Explain why the same reading was or was not obtained in steps four and five.

____

____

____

7. Test the positive section of a circuit by clipping one of an analog voltmeter's leads to a good ground and touching several points in the positive section of the circuit. Record your results.

____

____

____

8. Repeat the procedure using a digital voltmeter. Record your results.

____

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____

9. Test the negative section of a circuit by clipping one lead of a voltmeter to a good ground and touching several points in the negative section of a circuit. Record your results.

____

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____

10. Record what is wrong with the circuit and discuss with your instructor steps to repair the problem.

____

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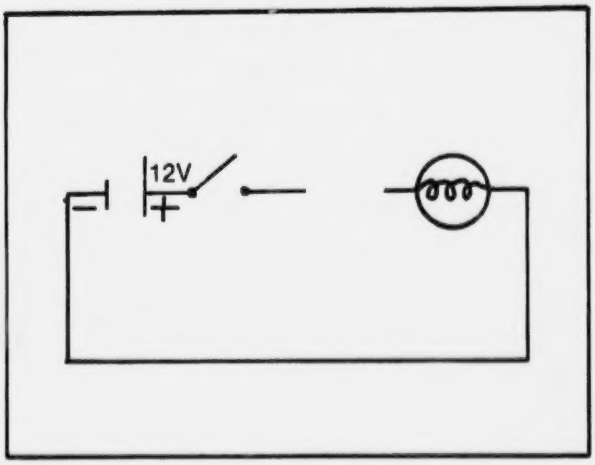
____

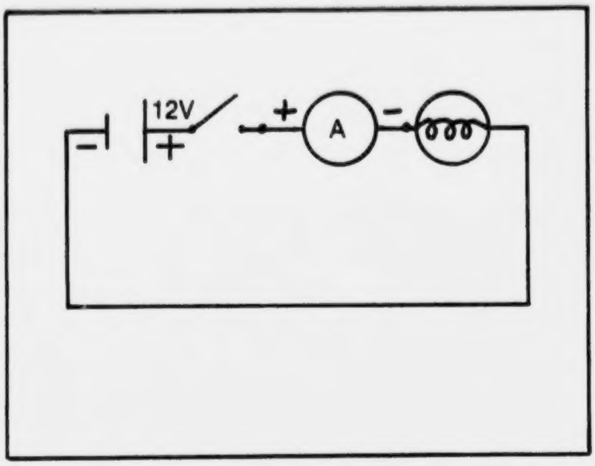
11. Put away your tools and clean up the work area.

G. Procedure for using an ammeter

1. Non-inductive style

This type of ammeter has two leads -- one positive and one negative.





a. Make sure the circuit is turned off.

b. Open the circuit.

c. Attach the ammeter's positive lead to the wire that goes most directly to the battery's positive post.

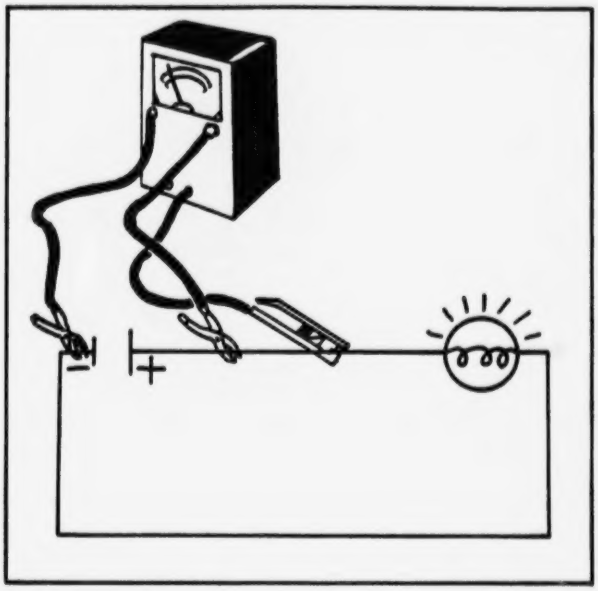
d. Attach the negative lead to the wire that goes most directly to the battery's negative post.

e. Adjust the ammeter to a range higher than the current flow rate for the circuit. If you are not sure of the current flow rate, always turn the ammeter to the highest range.

f. Turn the circuit on and read the current flow from the scale on the meter.

2. Inductive style

This type of ammeter has three leads -- (1)an inductive lead, which senses current flow, (2)a positive lead and (3)a negative lead, both of which power the meter.



a. Connect the positive lead to the battery's positive post.

b. Connect the negative lead to the battery's negative post.

c. Adjust the ammeter to a range higher than the current flow rate for the circuit. If you are not sure of the current flow rate, use the highest range possible.

d. Clamp the inductive lead around the circuit you want to test.

e. With the circuit operating, read the current flow from the scale on the meter.

DO SKILL SHEET 7

DO ACTIVITY SHEET 5

SKILL SHEET 7

Directions: Complete the following statements with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

parallel
vehicle
range
power
circuit
series
negative
positive

1. A non-inductive ammeter connects in ______________________________ with the circuit.
2. A non-inductive ammeter's positive lead must always attach to the wire that goes most directly to the battery's _________________ post.
3. An inductive pickup attaches around any wire in the ____________________ that you want to measure.
4. When using either style of ammeter to measure current, make sure the meter is adjusted to a higher ____________________________ than the current flow in the circuit.
5. The positive and negative leads on an inductive-style ammeter are used to ___________________________________ the meter.

MEASURING CURRENT WITH AN AMMETER

ACTIVITY SHEET 5

1. See your instructor to get a car that needs the current flow in a circuit tested.

2. Review the procedure outlined in this unit and the appropriate service manual.

3. Secure the tools and equipment needed. WEAR SAFETY GLASSES!

4. Using a non-inductive, analog type of ammeter, measure the current flow. Record your results.

5. Repeat the procedure using an inductive-style ammeter. Record your results.

6. Explain why the same reading was or was not obtained in steps four and five.

Put away your tools and clean up the work area.

USING METERS TO TEST WIRING AND SWITCHES

UNIT REVIEW

1. Jumper wires are used primarily to check for __________.

   a. breaks in a circuit
   b. grounds

2. A non-inductive ammeter connects in series with the circuit to be tested.

   TRUE FALSE

3. A test light can be used to check for breaks in a circuit.

   TRUE FALSE

4. A voltmeter is used to measure resistance in a circuit.

   TRUE FALSE

5. Infinite resistance means the current has been stopped somewhere between the part of the circuit being tested and the ground.

   TRUE FALSE

USING METERS TO TEST WIRING AND SWITCHES

PERFORMANCE CHECKLIST

Student ______________________ successfully performed the following tasks:

	Yes	No	Comments
1. Used a jumper wire to bypass a circuit			
2. Used a test light to find a problem in at least 3 circuits			
3. Used an Ohmmeter to measure resistance in at least 3 circuits			
4. Used an Ohmmeter to find breaks and grounds in at least three circuits			
5. Used a voltmeter to measure voltage in at least three circuits			
6. Used an ammeter to measure current in at least three circuits			

Satisfactory - should move on ☐

Should repeat this unit ☐

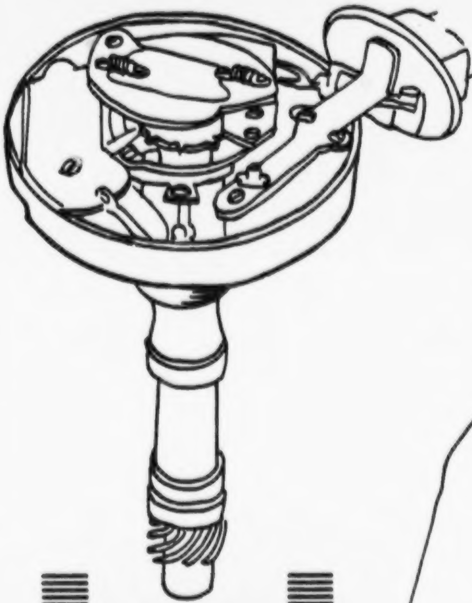
____
Student's Signature/Date

____
Instructor's Signature/Date

90-6020-S

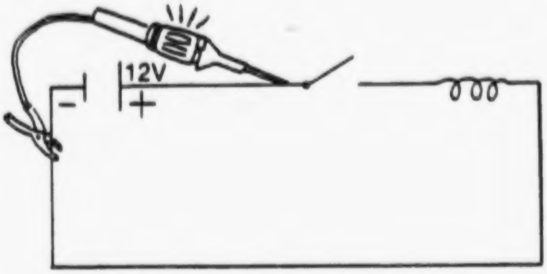
Auto Mechanics

Supplementary Units



PRODUCED BY
INSTRUCTIONAL MATERIALS LABORATORY
UNIVERSITY OF MISSOURI-COLUMBIA
COLUMBIA, MO 65211

Unit 8



Testing a Charging System

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TESTING A CHARGING SYSTEM

INTRODUCTION

In this unit, you will use the basic checks involved in servicing a charging system. The charging system is the heart of the electrical system. It not only keeps the battery charged, but also maintains all the accessories that keep the vehicle running.

UNIT OBJECTIVE

After you complete this unit, you will be able to diagnose and correct problems in the charging system.

SPECIFIC OBJECTIVES

After completing this unit you will be able to specifically:

1. Use an ammeter and voltmeter to determine charging current and charging voltage.
2. Use a jumper wire to bypass the voltage regulator and wiring harness.
3. Perform positive and negative diode tests.
4. Perform a rotor and brush continuity test.
5. Check belt tension.

Check the Statement that Fits You Best.

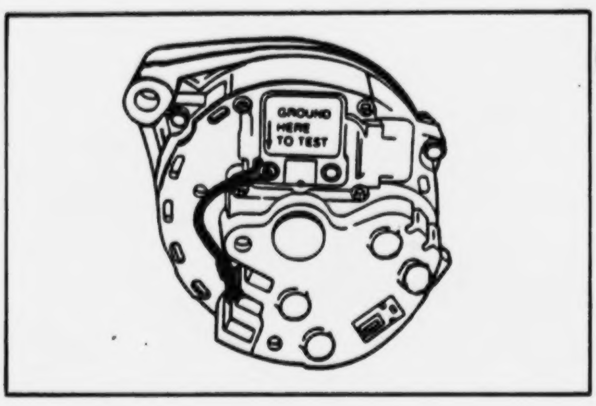
☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

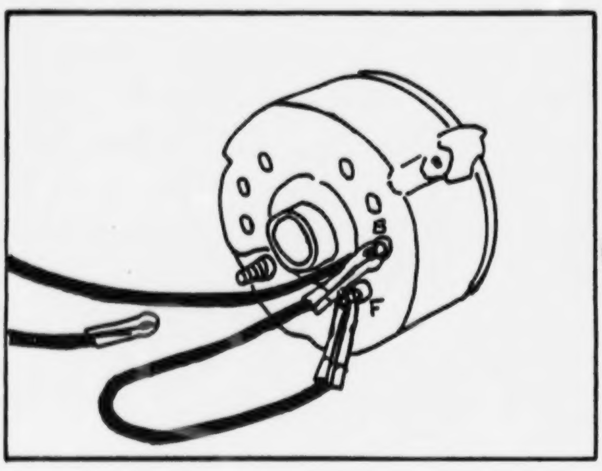
☐ **I want to study the information in this unit before I do the Performance Checklist.**

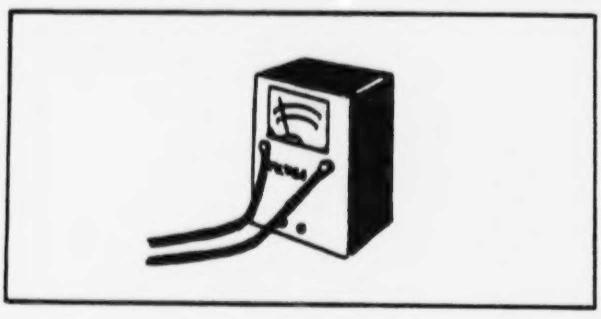
TURN PAGE AND BEGIN

On Ford cars, insert a jumper wire between the voltage regulator test terminal on the back of the alternator and a good ground.



1. Connect a voltmeter to the battery, hooking the positive lead to the positive post and the negative lead to the negative post.
2. On cars with external voltage regulators:
   a. remove the field wire from the back of the alternator.
   b. attach one end of jumper wire to field terminal "F" on the back of the alternator.
   c. start the engine and bring it up to 1500 r.p.m.
   d. hold the other end of the field terminal on the battery "B" terminal of the alternator.
   e. observe the voltage reading.
   f. turn the engine off and remove the jumper.
   g. reconnect field terminal "F."



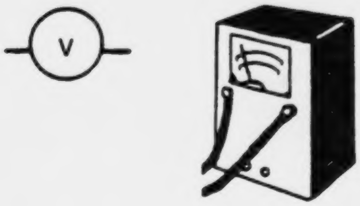


A. Terms

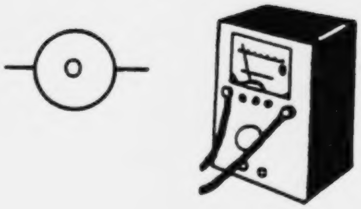
1. **Alternator** - the part of the charging system that produces the electric current stored in the battery to start the car.
2. **Ammeter** - the instrument used to measure current flow.
3. **Circuit** - the path of electricity through the car's electrical system.
4. **Diode** - a device that lets electricity pass in one direction but prevents it from going in the opposite direction.
5. **Ohm** - a unit for measuring resistance to electric current in a circuit.
6. **Ohmmeter** - the instrument used to measure resistance to electric current.
7. **Rectifier** - a device that changes current from AC (alternating current) to DC (direct current).
8. **Rotor** - a part in the alternator that turns.
9. **Stator** - the wiring in the alternator that remains stationary.
10. **Transistorized regulator** - a device that controls the alternator voltage.
11. **Volt** - a unit for measuring electrical pressure.
12. **Voltmeter** - the instrument used to measure electrical pressure.

Equipment

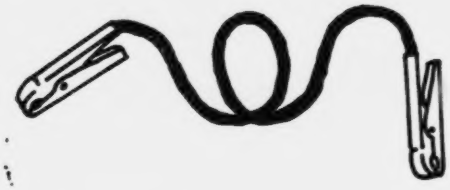
Voltmeter



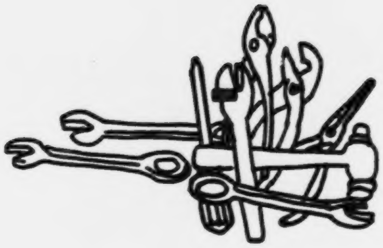
Ohmmeter



Jumper wire

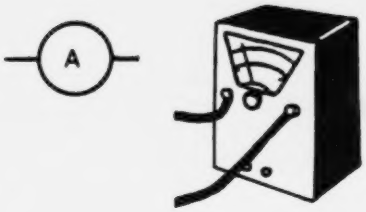


Hand tools



Specifications manual

Ammeter



Safety glasses

B. Introduction

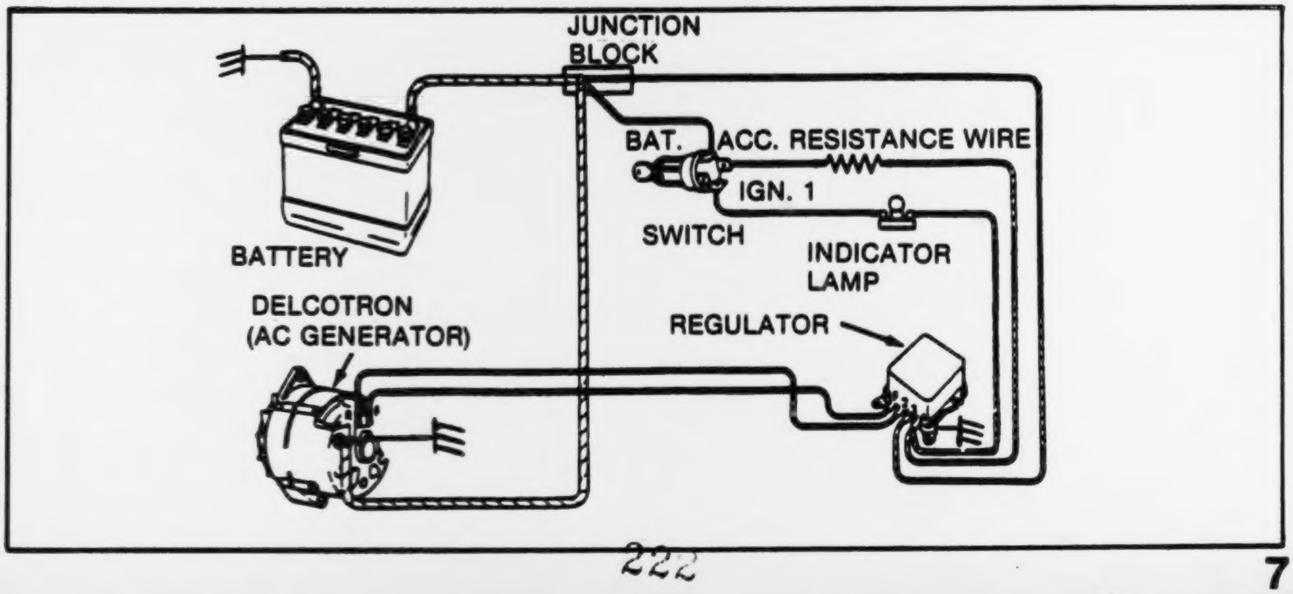
The charging system converts mechanical energy into electrical current. The alternator is a main part of the charging system. The alternator recharges the battery and supplies electricity to power the vehicle while the engine is running.

You need to organize your test procedures carefully because the failure of one part may cause another to fail or act up. Your test results must be very accurate because the manufacturer's specifications are very precise.

You should carefully test a charging system that only puts out slightly less than specifications. Dim headlights or hard starting, for instance, can mean the battery or alternator is not doing its job. Most alternators are stamped with a rating. If not, the rating can be found in service manuals.

Charging system service and repair can be divided into three areas:
(1)visual inspection,
(2)performance testing and
(3)system service.

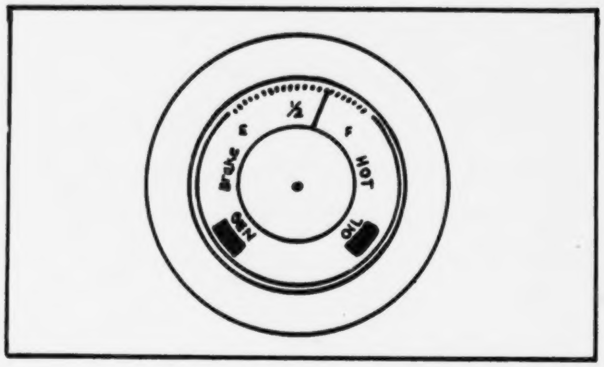
If you think the charging system might be failing, you need to first verify the problem through a visual (using eyes) inspection or a performance test.



C. Types of visual inspection

There are several ways to visually check for alternator problems. You should start by checking the indicator light circuit.

1. Indicator light circuit check



The alternator indicator light is often the driver's only way to tell if the charging system is working properly.

The driver can check the light each time he or she starts the car.

There are two conditions to look for. The first is when the light doesn't come on. The second is when the light comes on at the wrong time.

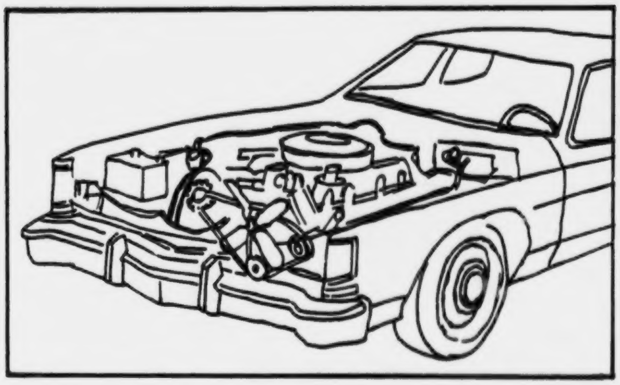
Watch the light under the following conditions:

Key position	How light should look
(1)OFF	OUT
(2)ON(engine not running)	ON
(3)Start	ON
(4)ON(engine running)	OFF
(5)Accessory	ON or dim

2. Under-the-hood check

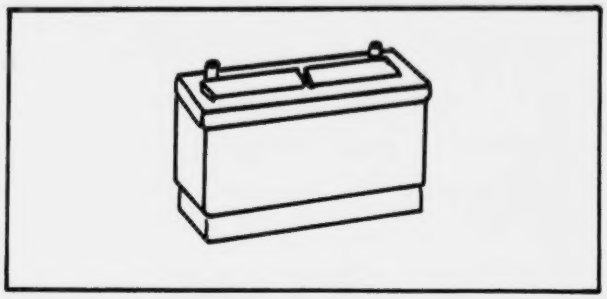
The next thing to do is to look under the hood.

a. Raise the car's hood and locate the battery, alternator and voltage regulator.

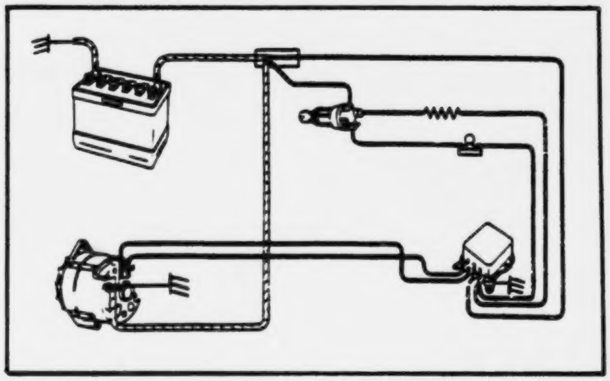


b. Make sure you are testing a fully charged battery.

NOTE: Battery testing and charging is not covered in this unit. See your instructor for more information.

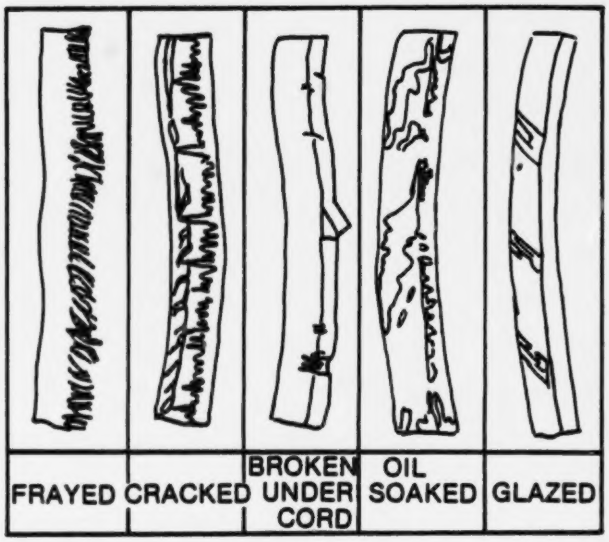


c. Look at the wiring and connections for signs of high resistance, defective wire and faulty or loose connections.

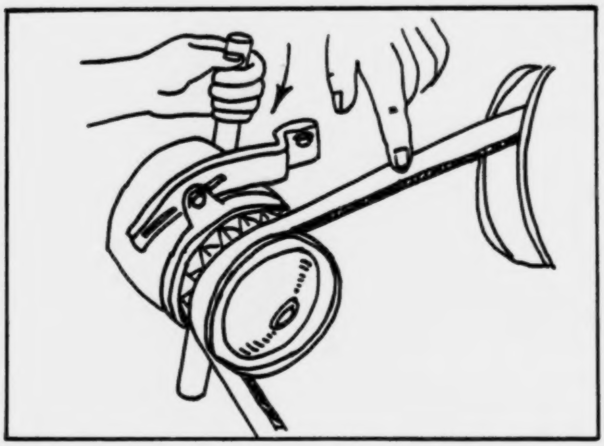


d. Look at the condition of all belts.

Are the belts:
(1)frayed?
(2)cracked?
(3)getting broken cords?
(4)oil-soaked?
(5)glazed?

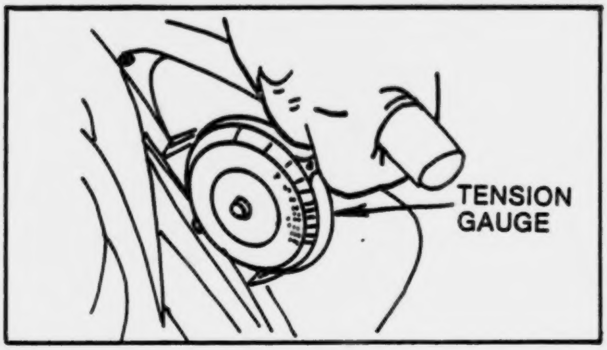


3. Check the belt tightness.



The alternator belt should be properly adjusted because:

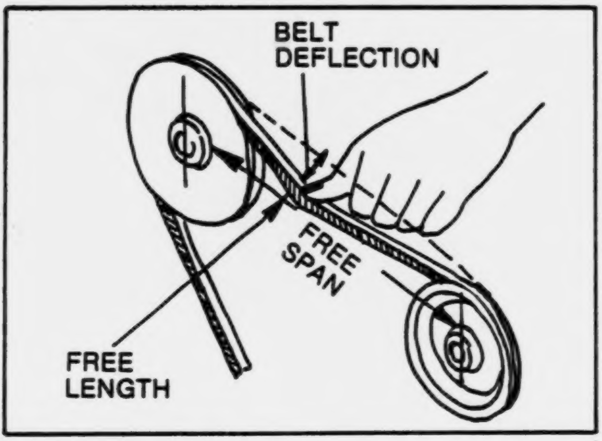
- loose belts allow the alternator drive pulley to slip. Over a period of time, a slipping drive pulley causes an under-charged battery.



- Belts that are too tight put too much pressure on the water pump and alternator bearings. This pressure can cause the bearings to fail before they normally would.

- Several tool companies make gauges for checking belt tension and most belt makers give torque tension specifications.

If no gauge is available, a good rule of thumb is to adjust the belt to allow for one half inch (1/2") of free travel in each direction from the center and one inch (1") of total free travel up and down, when measured at the center of the longer span of belt.

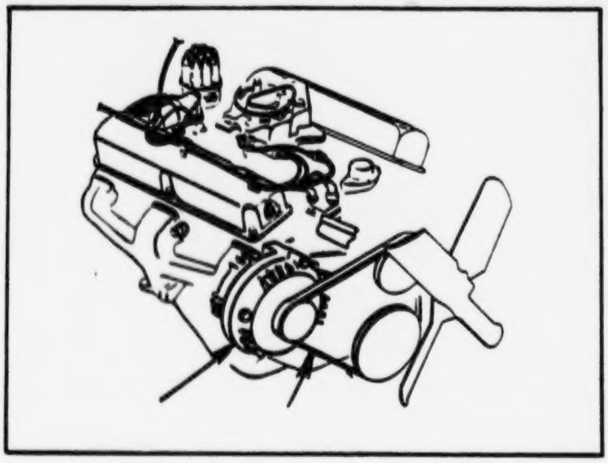


4. Start the engine and listen for extreme alternator noise. Be careful not to confuse other engine noise with alternator noise. An automotive stethoscope may make the job easier. Listen for the following noises:

   (1)squealing noise - (bad drive belt or alternator bearing)

   (2)grinding noise - (bad alternator bearing)

   (3)whining noise - (bad alternator diodes)



DO SKILL SHEET 1

DO ACTIVITY SHEET 1

SKILL SHEET 1

Complete the following statement with the proper word or phrase. If you are unsure of an answer, look back at the text for help.

1. The charging system (does, does not) change mechanical energy into electrical current.

2. On many alternators, the specifications (are, are not) stamped on the case.

3. Before performing any alternator test, the battery (must, must not) be fully charged.

4. A loose alternator belt (can, cannot) stop the battery from properly recharging.

5. A whining noise from the alternator (is, is not) an indication of a failed diode.

ACTIVITY SHEET 1

1. See your instructor to get a car that needs its charging system serviced.
2. Review the procedure outlined in this unit and in the appropriate service manual for the car.
3. Secure the tools and equipment needed. WEAR SAFETY GLASSES!
4. Determine the manufacturer's specifications.

   volts __________
   amps __________

5. Begin a visual inspection by checking the indicator light circuit.

   Record your results:

Key position	Expected result	O.K.	Not O.K.
1. OFF		☐	☐
2. ON (Engine not running)		☐	☐
3. START		☐	☐
4. ON (Engine running)		☐	☐
5. ACCESSORY		☐	☐

6. Finish the visual inspection by checking under the hood.

   Record your results:

Battery:	O.K.	☐	Need changing	☐
Belts:	O.K.	☐	Not O.K.	☐

If not O.K., list problems with the belts:

Belt tension specification

O.K. ☐ Not O.K. ☐

Alternator noise

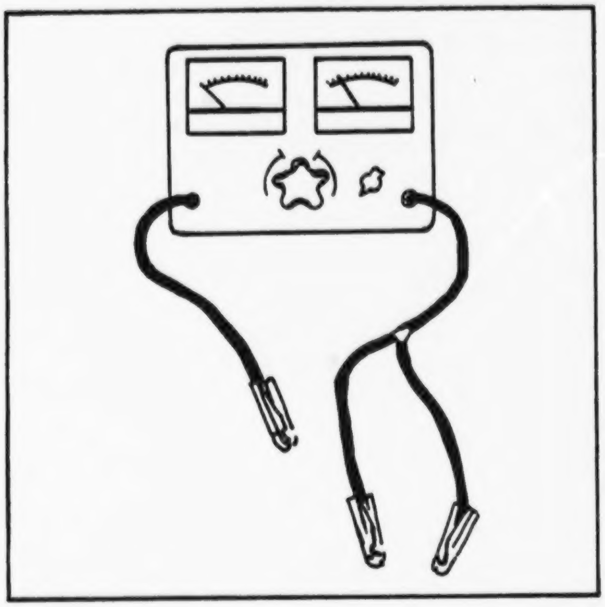
O.K. ☐ Not O.K. ☐
If not O.K., explain the noise:

7. Discuss the results with your instructor and determine the appropriate action.

8. Put away your tools and equipment and clean up the work area.

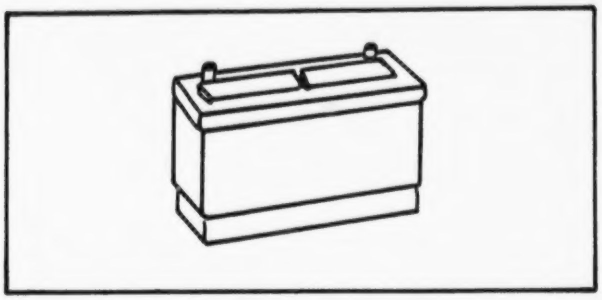
D. Alternator performance test

You will need a VAT (Volts-Amps Tester) to perform this test.



1. Determine the manufacturer's specification for the alternator. (It should be stamped on the alternator housing or listed in the service manual.)

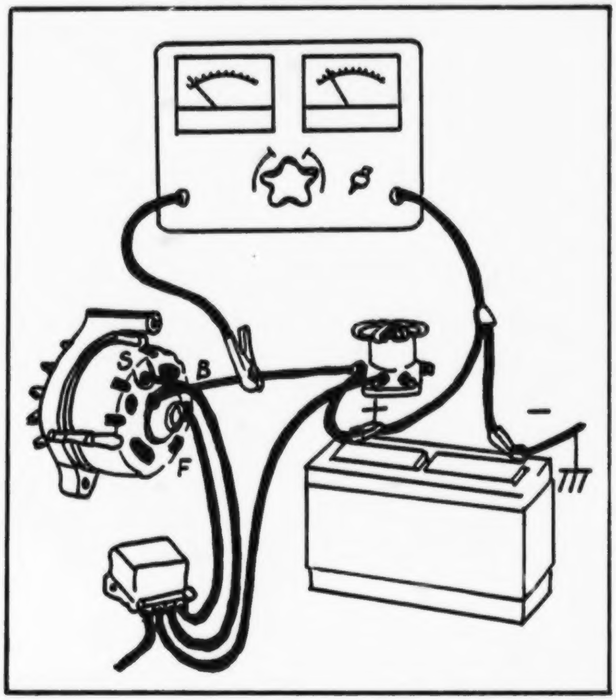
   volts ___________
   amps ___________



2. Make sure the battery is charged and the system passed the visual inspection test.

3. Place the Inductive Pickup Clamp around the output wire on the back of the alternator.

4. Make sure the load control knob of the VAT is turned "off" (at the maximum counter-clockwise position).

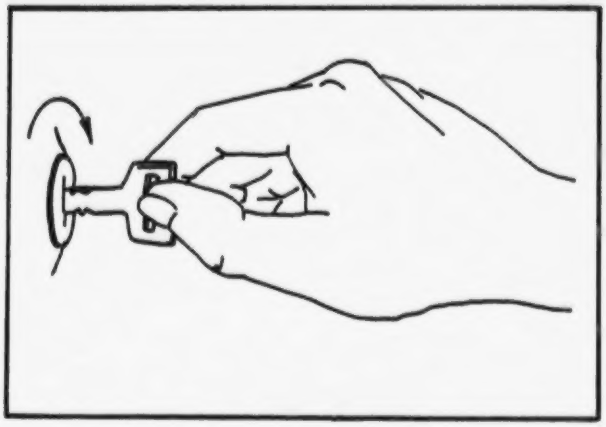


5. Connect the voltmeter test leads to the battery terminals. Red attaches to positive and black attaches to negative.

6. Record the battery voltage (open circuit voltage).

   ____________________volts

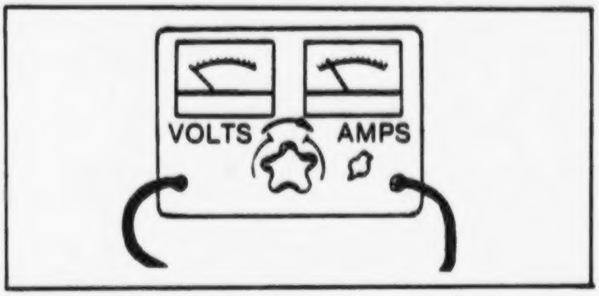
7. Start the engine and run it at 1500 to 2000 r.p.m.



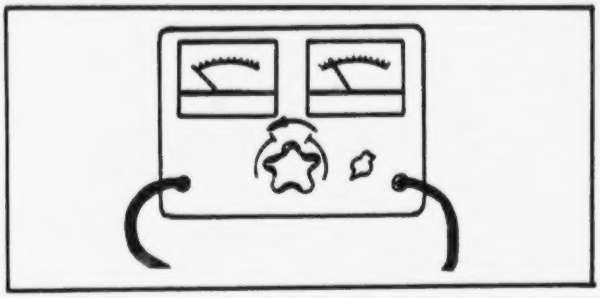
8. Switch the tester to the charging system test position.

9. With the engine at 1500 to 2000 r.p.m., turn the load knob until highest amps are achieved, but do not let the voltage drop below 12 volts.

   (Remember the ammeter and voltmeter readings.)



10. Turn the load knob off, return the engine to idle and shut it off.



11. Record the reading:
    Volts __________
    Amps __________

12. The voltage should be within the manufacturer's specification range and at least one volt greater than the open circuit voltage recorded in step 6.

13. The amperage should be within five amperes of the manufacturer's specification.

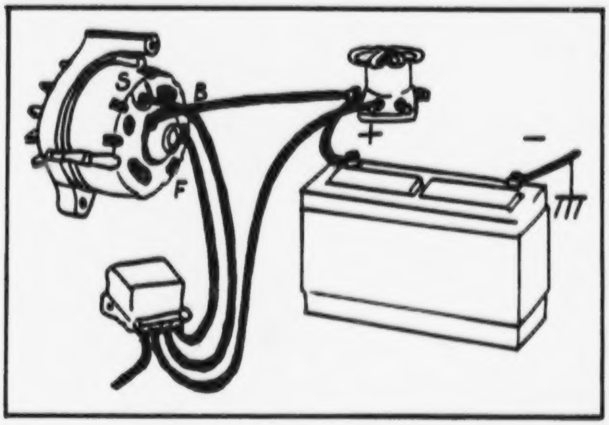
    O.K. ☐ Not O.K. ☐

14. Put away your equipment and clean up the work area.

231

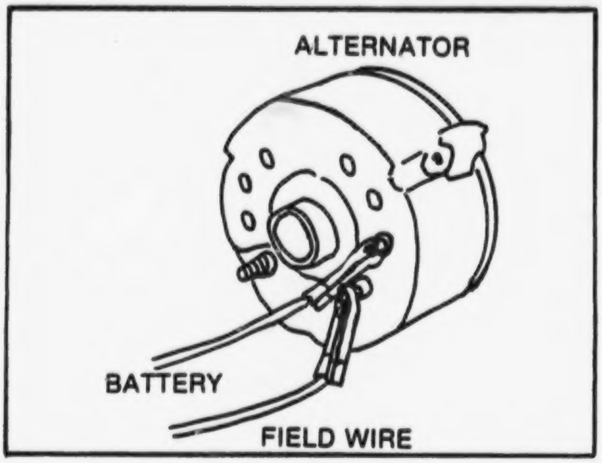
E. Alternator Maximum output test (Full-field test)

If the alternator fails the performance test, the technician does not know if the failed test comes from a bad voltage regulator or a bad alternator.



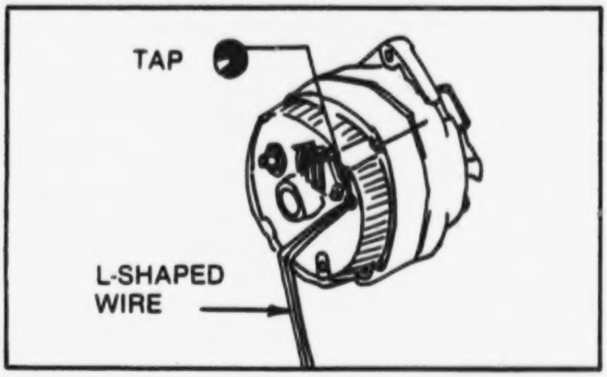
One of the best ways to tell which part is bad is to take the regulator out of the system.

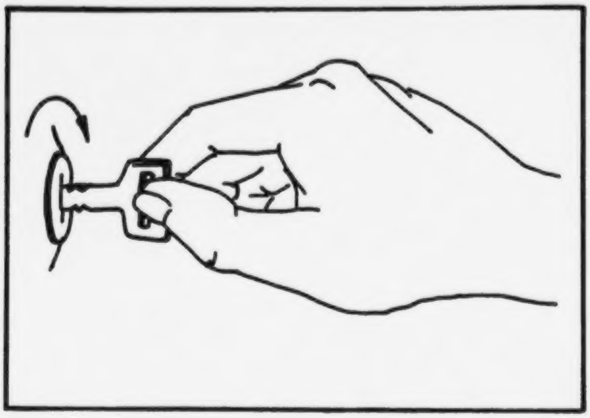
An "external" type of regulator is taken out by unplugging the field lead from the alternator and connecting an external current supply to excite the field.



An 'internal" type of regulator is taken out by forcing the field circuit to ground before the voltage regulator.

On General Motors cars, insert a screwdriver or small "L"-shaped wire into the test hole on the back of the alternator. The tool should be pushed in only far enough to touch the tap. If the tool is pushed in too far, the alternator may be damaged.





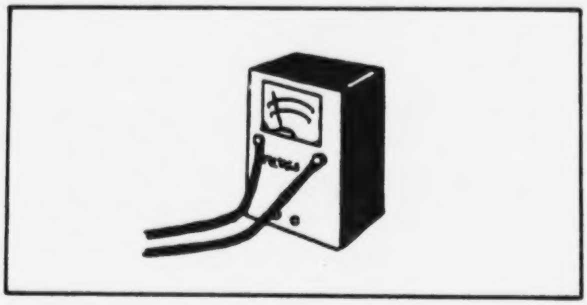
3. On a car with an internal regulator:

   a. start the engine and bring it up to 1500 r.p.m.

   b. use jumper wire or tool to ground the field circuit.

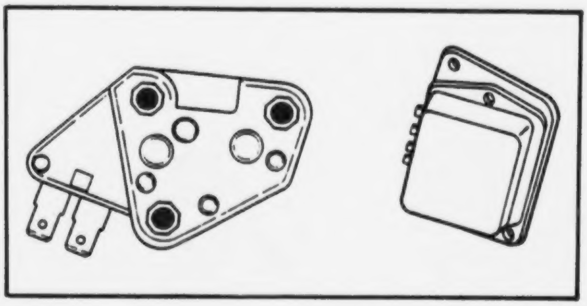
   c. observe the voltage reading.

   d. turn the engine off and remove the jumper on the field.



4. Record your results.

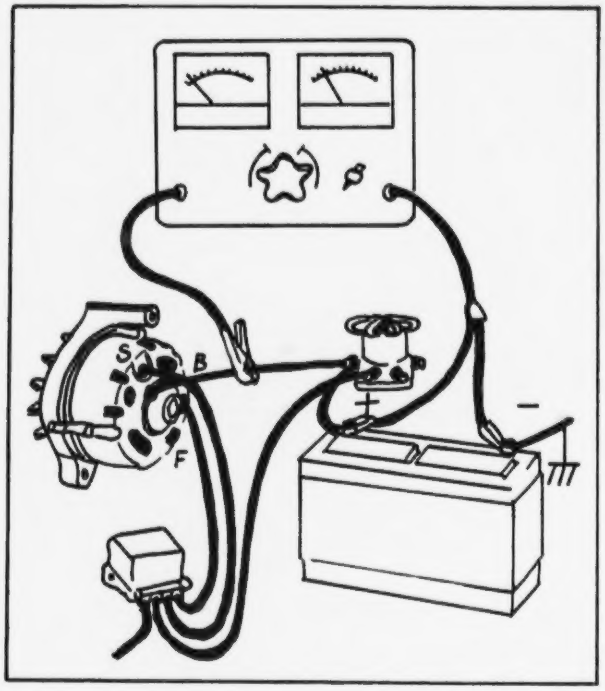
CAUTION: Never let the voltage go above 16 volts, or damage can occur to the car's electrical system.



- Voltage should rise to 15 or more volts. If voltage rises, the field circuit wiring or regulator is bad and needs to be fixed or replaced.

- If the voltage does not rise, the problem must be in the alternator.

5. Make the needed repairs, or replace the defective voltage regulator.



6. Repeat the performance test on the charging system.

7. Put away your equipment and clean up the work area.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

SKILL SHEET 2

Directions: Before testing the alternator on the car, answer the following questions. If you are not sure of an answer, look back at the text for help.

1. During the alternator performance test, the engine (should, should not) be at idle.

2. During the alternator performance test, the voltage should not drop below (12, 14, 16) volts.

3. In the alternator full-field test, the (alternator, regulator) is bypassed.

4. On the alternator full-field test, never allow the charging system voltage to go above (12, 14, 16) volts.

5. If the alternator checks out O.K. in a full-field test, the (alternator, regulator) must be bad.

TESTING THE ALTERNATOR
ACTIVITY SHEET 2

1. See your instructor to get a car that needs its charging system serviced.

2. Review the procedure outlined in this unit and the appropriate service manual for the car.

3. Secure tools and equipment. WEAR SAFETY GLASSES.

4. Complete the alternator performance test.

Record your results:

Specifications	Results	O.K.	Not O.K.
Volts ______	______		
Amps ______	______	☐	☐

6. Discuss your results with your instructor and determine appropriate action.

7. Complete the alternator maximum output test. WEAR SAFETY GLASSES.

Record your results.

O.K. ☐ Not O.K. ☐

8. Discuss your results with your instructor and decide on the proper action to take.

9. Put away your equipment and clean up the work area.

F. Diode Test

The diode is a solid state electrical device that only allows current to flow in one direction. The diode is used inside the alternator to control the current.

There are six main diodes in the alternator. The six diodes produce the electricity required to run the car and recharge the battery.

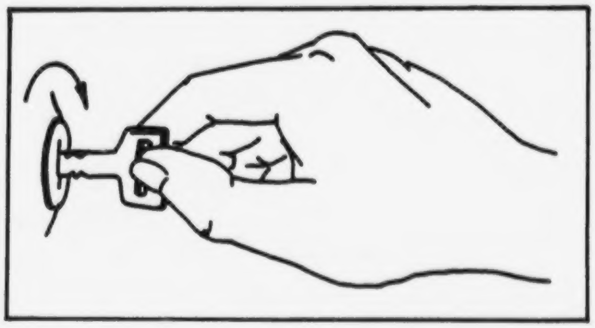
The diodes are the most vulnerable parts of the alternator. Heat is their number one enemy. Any sudden surge of voltage or current can cause the diodes to fail.

The diode test can show a diode failure. But the test cannot show you which diode has failed. If the test indicates diode failure, the alternator should be taken apart so each diode can be tested on its own.

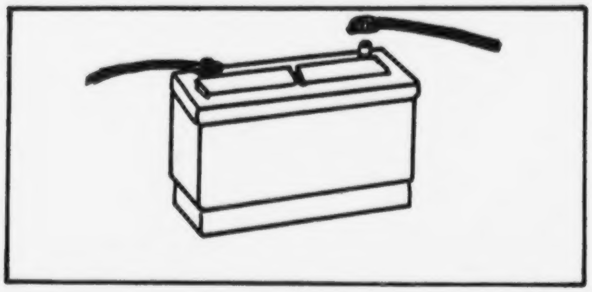
There are two types of on-car diode tests. The first is a dynamic (operational) test that requires a special tester or a VAT with a built-in diode tester.

The second test -- the test in this unit -- is a static (the system will not be operating) test. It uses an ohmmeter.

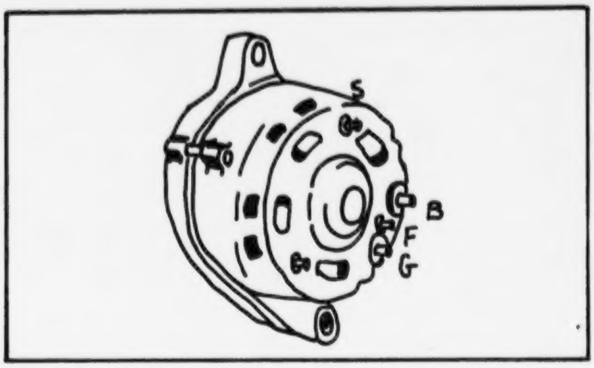
1. Put on your safety glasses.
2. Make sure the key is in the "off" position.



3. Remove the negative battery terminal.



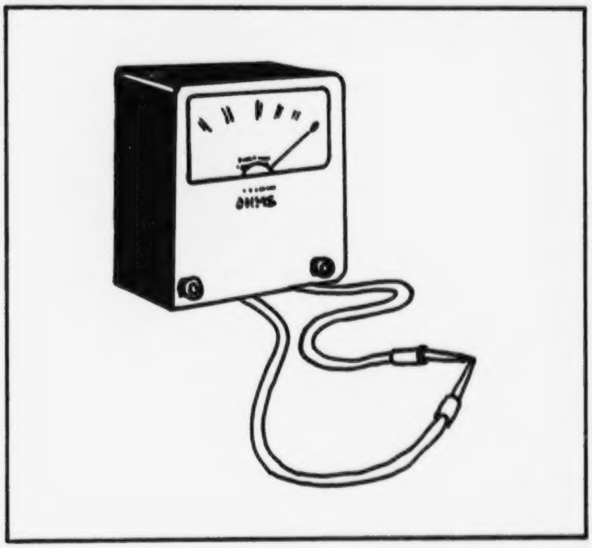
4. Remove the alternator drive belt and position the alternator so that the terminals on its back are handy.



5. Remove the wiring harness from the back of the alternator.

6. Perform a positive diode test.

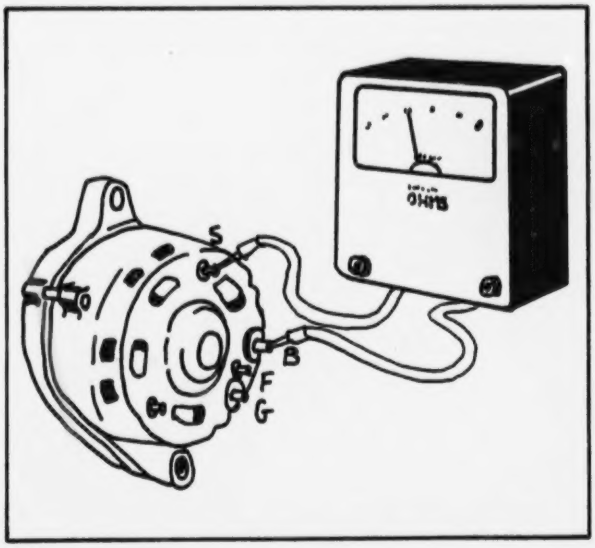
   a. Get an ohmmeter and set its selector switch on the 100 ohm scale.



   b. "Zero" the meter by touching its leads together and turning the "ohms calibrate" knob until the needle points to zero.

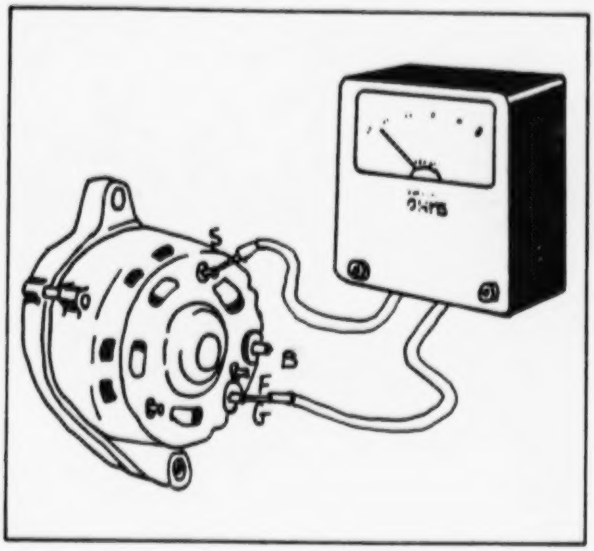
   c. Touch one probe to the alternator "BAT" terminal and the other probe to the "STA" terminal.

   You should get a reading of about 60 ohms in this direction.



d. Check continuity in the other direction by reversing the probes.

You should get an infinite reading (no needle movement) in this direction.



e. A reading of 60 ohms or less in both directions may mean:

- A defective positive diode
- A grounded positive diode plate
- A grounded alternator "BAT" terminal

f. An infinite reading (no needle movement) in both directions means an open "STA" terminal connection.

g. Record your results.

7. Perform a negative diode test.

   a. Set the ohmmeter selector switch on the 100 ohm scale.

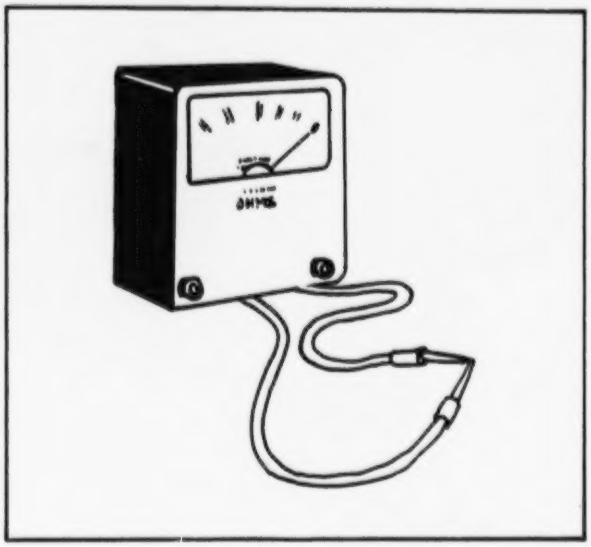
   b. Zero the meter.

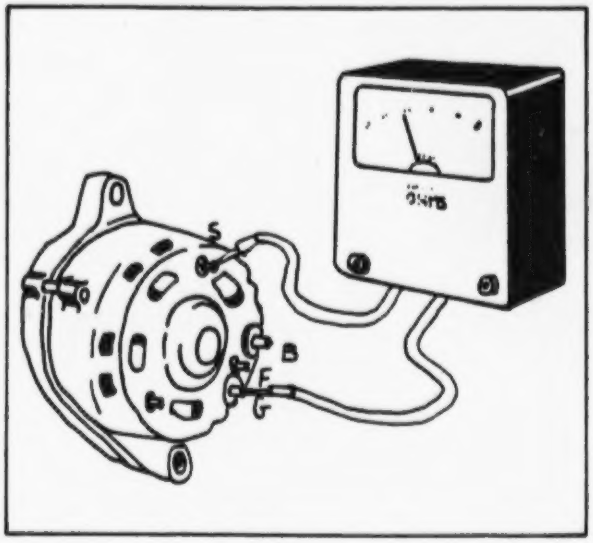
   c. Touch one probe to the "STA" terminal and the other probe to the "GRD" terminal.

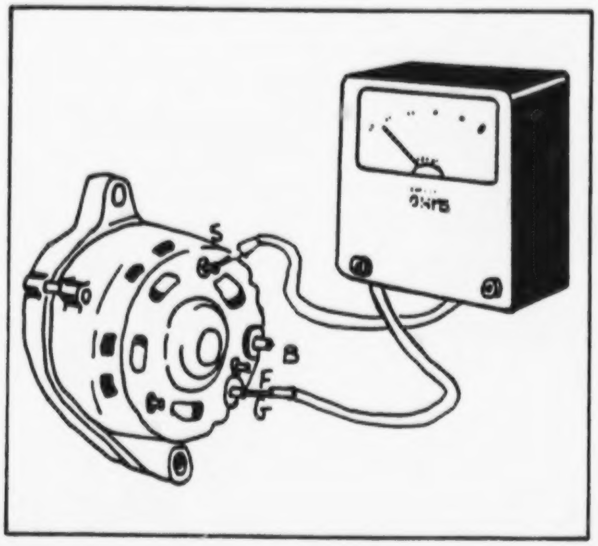
      You should get a reading of about 60 ohms in this direction.

   d. Check continuity in the other direction by reversing the probes.

      You should get an infinite reading (no needle movement) in this direction.







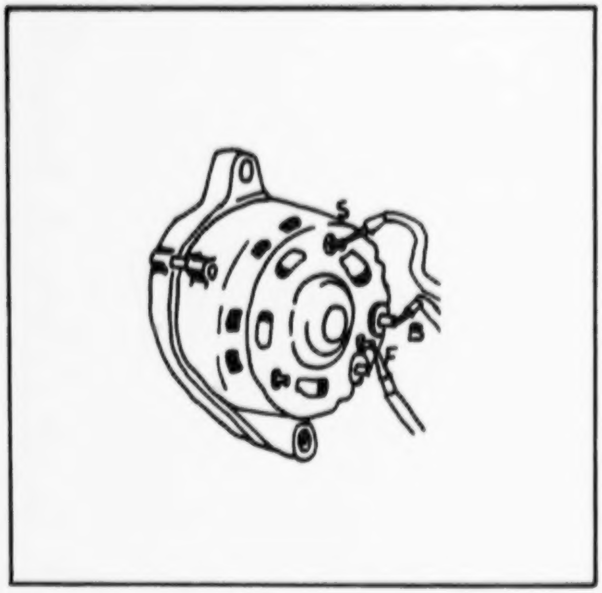
e. A reading of 60 ohms or less in both directions may mean:

- A defective negative diode
- A grounded positive diode plate
- A grounded alternator "BAT" terminal
- A grounded "STA" terminal
- A grounded stator winding (The laminations or windings could be grounded to the front or rear housing.)

f. An infinite reading (no needle movement) means an open "STA" terminal connection.

g. Record your results.

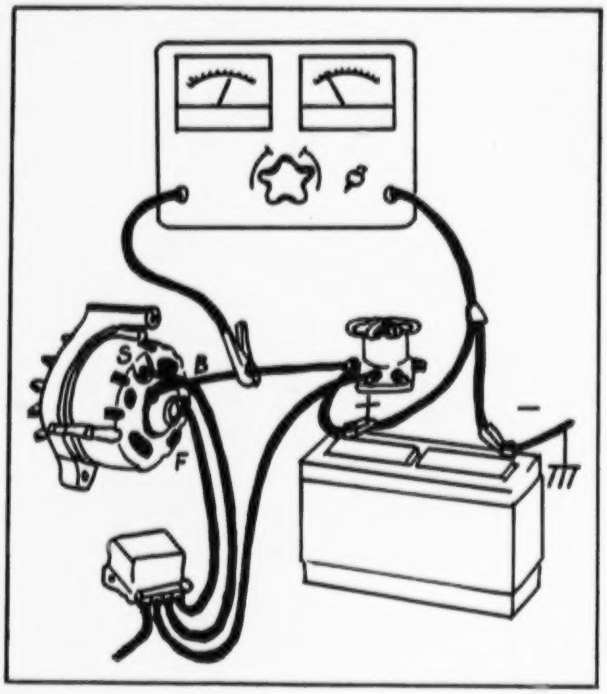
h. Make the needed repairs.



i. Connect the wiring harness to the back of the alternator.

j. Install the drive belt.

k. Connect the negative battery terminal to the battery.



l. Repeat the performance test on the charging system.

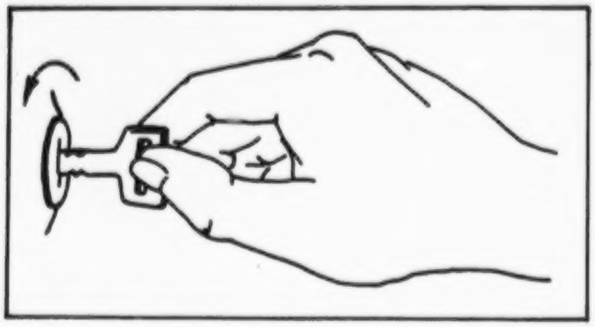
m. Put away your equipment and clean up the work area.

G. Rotor and brush continuity test

The brushes carry field current to the rotor. The rotor is a coil of wire wrapped around an iron core that is surrounded by a group of north and south magnetic field poles.

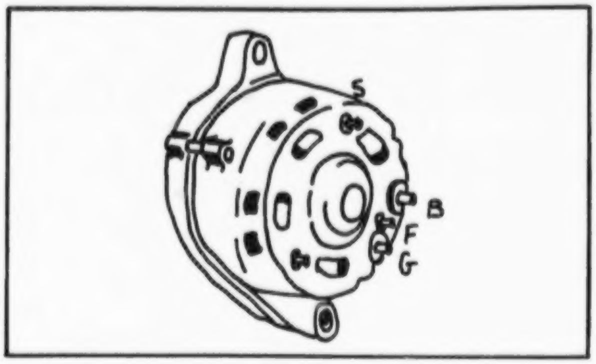
The job of the rotor is to rotate inside the alternator. This rotation produces the voltage needed to power the car and recharge the battery.

1. Make sure the key is in the "off" position.



2. Remove the negative battery terminal from the battery.

3. Remove the alternator drive belt and position the alternator so the terminals on its back are handy.

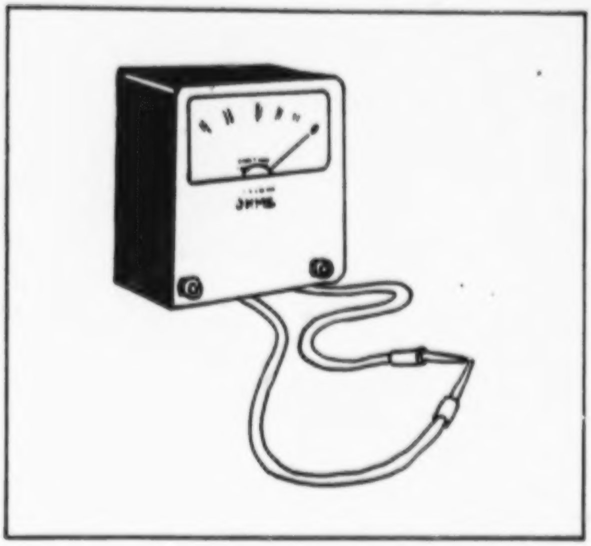


4. Remove the wiring harness from the back of the alternator.

5. Perform the rotor and brush test:

   a. Set the ohmmeter selector switch at 1,000 ohm scale.

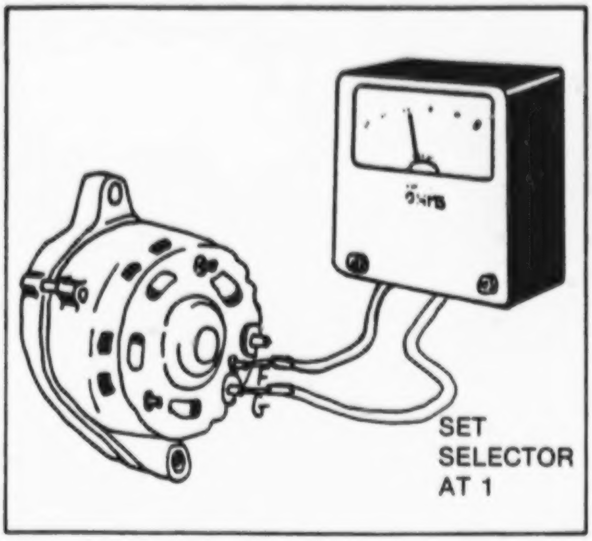
b. Zero the meter.



c. Touch one probe to the "FLD" terminal and the other probe to the "GRD" terminal.

d. Spin the pulley and note the ohmmeter reading.

The reading should fall between 4 and 200 ohms and fluctuate while the rotor is turning.



SET
SELECTOR
AT 1

A reading lower than 4 ohms indicates:

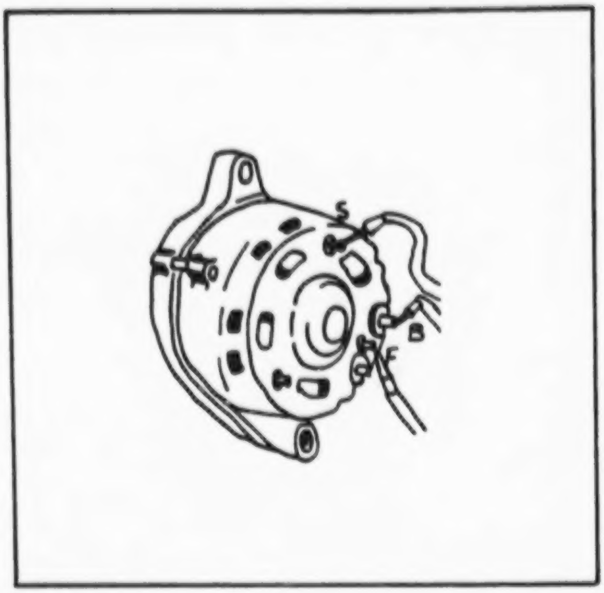
- a grounded positive brush
- a grounded field terminal
- a defective rotor

A reading higher than 200 ohms indicates:

- worn out or hung brushes
- an open brush lead
- a defective rotor

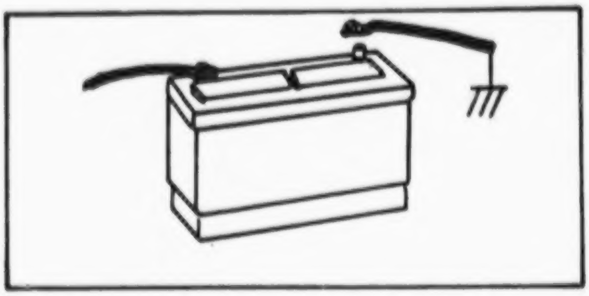
e. Record your results.

6. Make the needed repairs.



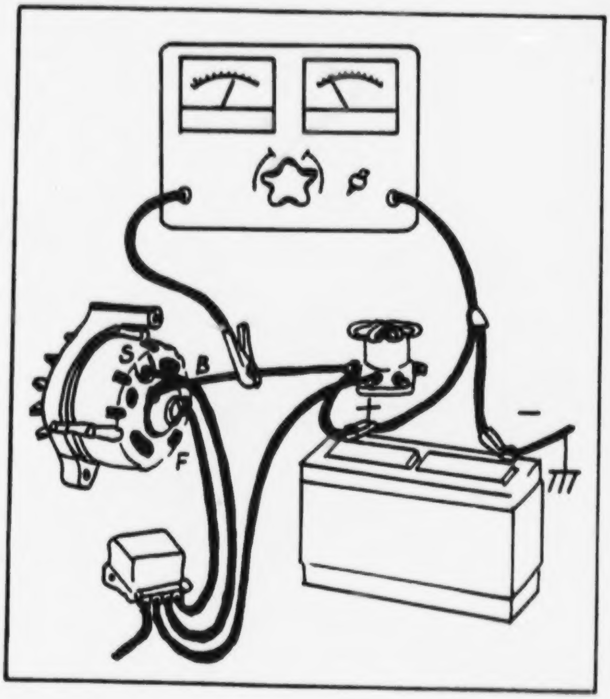
7. Connect the wiring harness to the back of the alternator.

8. Install the drive belt and adjust it to specification.



9. Connect the negative battery terminal to the battery.

10. Repeat the performance test.



11. Put away your tools and equipment and clean up the work area.

DO SKILL SHEET 3

DO ACTIVITY SHEET 3

SKILL SHEET 3

Directions: Before doing the Diode or Brush and Rotor tests, answer the following questions. If you are unsure of an answer, look back at the text for help.

1. The diode (does, does not) allow current to flow only in one direction inside the alternator.

2. During the diode test, you (must, must not) remove the wiring harness from the back of the alternator.

3. During the diode static test, the engine (is, is not) running.

4. The rotor (is, is not) an electro-magnet.

5. In the Brush and Rotor test, and ohmmeter reading of 550 ohms means the brushes (could, could not) be worn out.

TESTING THE DIODES

ACTIVITY SHEET 3

1. See your instructor to get a car that needs its charging system serviced.

2. Review the procedure in this unit and the proper service manual for the car.

3. Get the needed tools and equipment.

4. Perform a diode test. WEAR SAFETY GLASSES.

Record your results.

Positive diodes O.K. ☐ Not O.K. ☐
Negative diodes O.K. ☐ Not O.K. ☐

Discuss your results with your instructor and decide what to do about them.

5. Put away the tools and equipment and clean up the area.

TESTING A CHARGING SYSTEM

UNIT REVIEW

1. When the key is in the "on" position, but the engine is not running, the indicator light should be

   a. on. b. out. c. dim. d. blinking on and off.

2. When properly adjusted, how much free travel should the alternator belt have in its longest span?

   a. zero movement
   b. 1/2" movement in each direction
   c. 1 1/2" of movement in each direction
   d. none of the above

3. Which of the following will cause a diode to fail?

   a. Heat
   b. High voltage
   c. High current
   d. All of the above

4. When the alternator starts to produce electricity, the voltage should rise at least __________ volt(s) over the open circuit voltage.

   a. one
   b. three
   c. five
   d. ten

5. A diode is a solid state electrical device that stops all current flow.

   TRUE FALSE

TESTING A CHARGING SYSTEM

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Used an ammeter to determine charging current			
2. Used a voltmeter to determine charging voltage			
3. Used jumper wire to bypass the voltage regulator and wiring harness			
4. Performed a positive diode test			
5. Performed a negative diode test			
6. Performed a rotor and brush continuity test			
7. Checked belt tension			

Satisfactory - should move on ☐

Should repeat this unit ☐

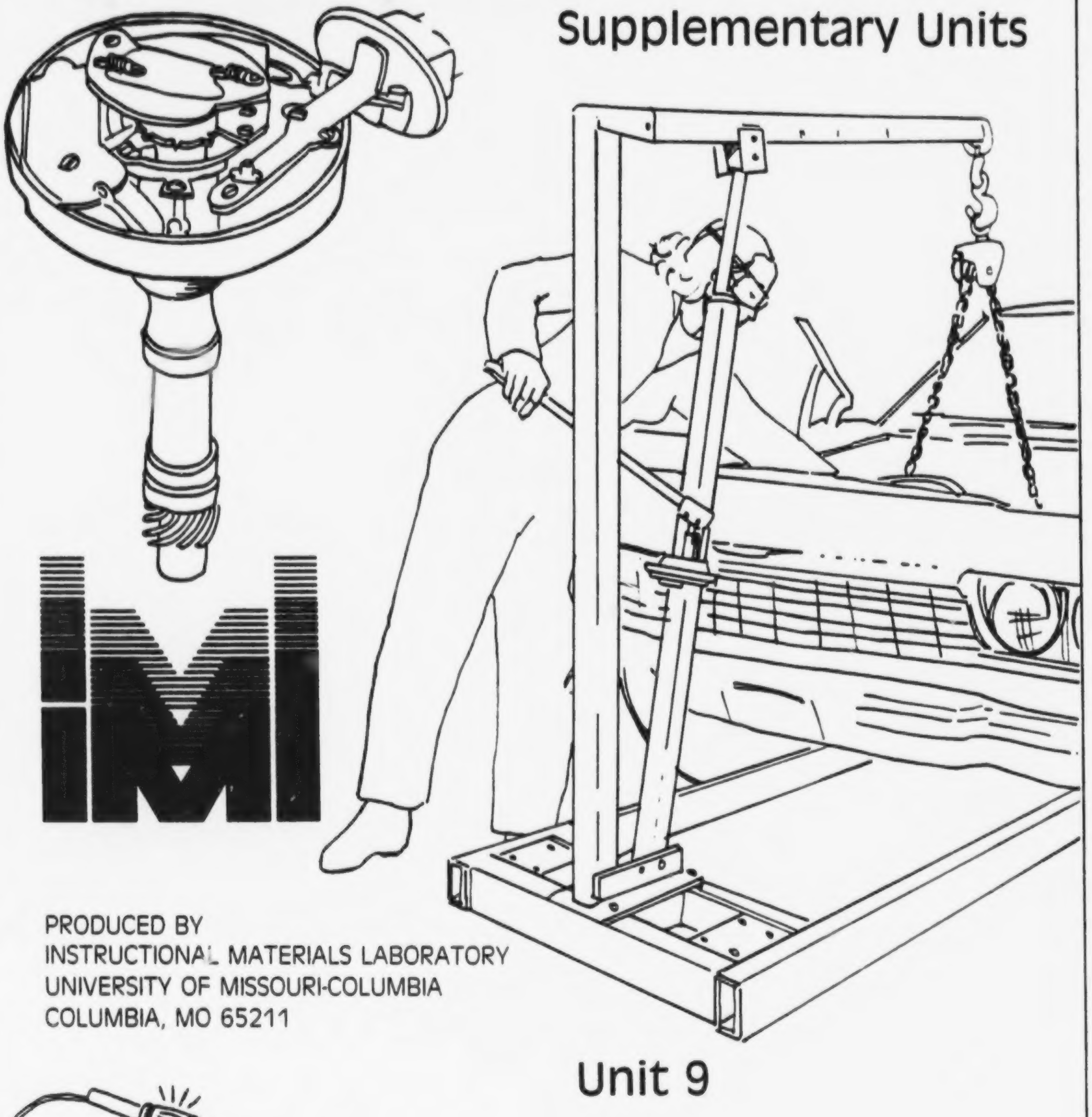
______________________________ ______________________________

Student's Signature/Date Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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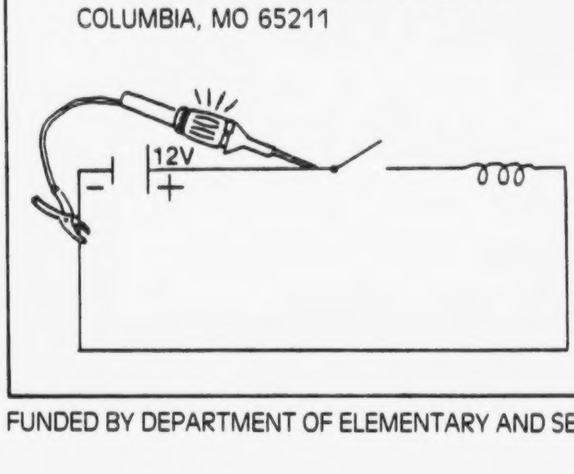
UNIVERSITY OF MISSOURI-COLUMBIA
COLUMBIA, MO 65211

Unit 9



Testing the Cranking System

FUNDED BY DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MO 65102

TESTING THE CRANKING SYSTEM

INTRODUCTION

The introduction of electric self-starters was one of the greatest advances in the evolution of the modern automobile. In the years since its invention, the starting system has been so thoroughly developed that now it is taken for granted.

Problems do arise, however, so the service technician needs to be familiar with all aspects of the starting system.

UNIT OBJECTIVES

After completing this unit, you will be able to diagnose and repair problems in the car's cranking system.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to specifically:

1. Locate and identify the major parts of a cranking system.
2. Describe the function of each major part in the cranking system.
3. Name the four most common problems in the cranking system.
4. Choose the appropriate tests to perform for each of the problems.

Check the Statement that Fits You Best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Ammeter** - the instrument used to measure the amount of current flowing in a circuit.

2. **Armature** - the portion of the starter (or generator) that revolves between the pole shoes and is made up of wire windings on an iron core.

3. **Battery** - a box filled with a water and acid solution that stores electric current.

4. **Field winding** - insulated wire wrapped around an iron or steel core; when current flows through the wire, a strong magnetic force field is built up.

5. **Ignition switch** - the slot in which the car key is turned to close the electrical circuit that starts the car.

6. **Negative battery cable** - the cable that conducts electric current back to the battery.

7. **Ohmmeter** - the instrument used to measure the amount of resistance to the flow of electricity in a given circuit.

8. **Positive battery cable** - the cable that conducts electrical currents into the car's electrical system.

9. **Relay** - a magnetically operated switch used to make and break the flow of electrical current in a circuit.

10. **Starter** - a small motor that causes the engine crankshaft to turn, which starts the car's engine running.

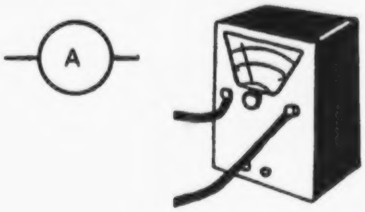
11. **Starter brushes** - the pieces of carbon or copper that rub against the commutator on the generator and starter motor.

12. **Starter drive or Bendix** - a starter drive gear that automatically engages when the starter starts spinning and disengages when the engine starts.

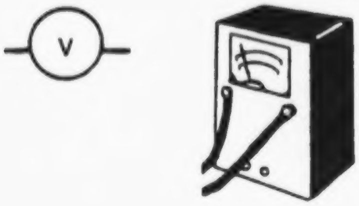
13. **Voltmeter** - the instrument used to measure the difference in electrical potential between one end of a circuit and the other.

Equipment

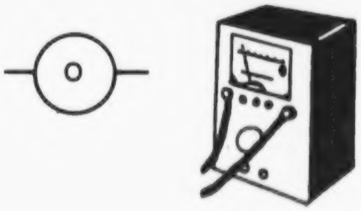
Ammeter



Voltmeter

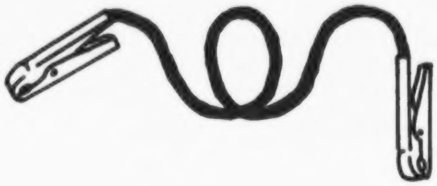


Ohmmeter

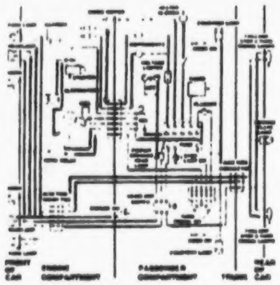


Service manuals

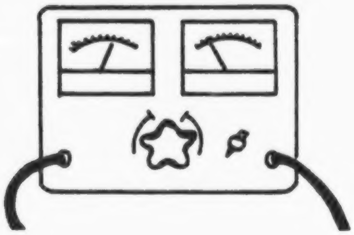
Jumper wires



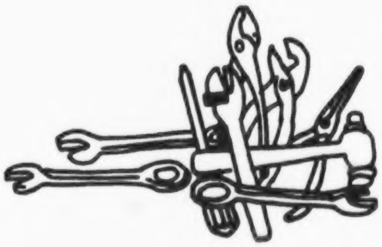
Wiring diagrams



VAT (Volts-Amps Tester)



Hand tools



B. Introduction

The job of the cranking circuit is to rotate the engine at a fast enough r.p.m. to allow the fuel and ignition systems to work properly.

The terms "cranking circuit" and "starting circuit" are often used interchangeably. However, it is best to use the correct name, the "cranking circuit."

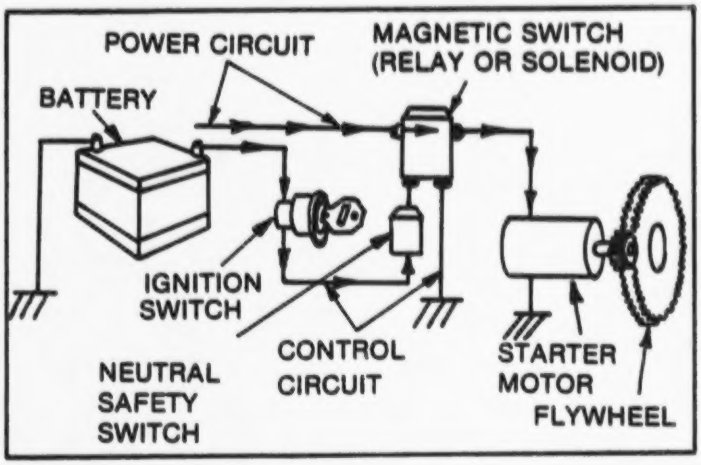
The cranking circuit consists of seven basic components and is divided into two smaller circuits, the control circuit and the ignition circuit.

The control circuit allows a small amount of current, usually less than five amps, to control the flow of the large amount of current needed to power the starter motor.

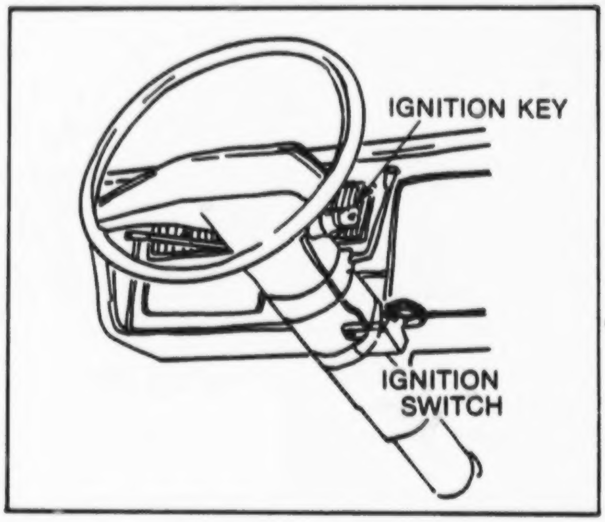
The power circuit sends the large amount of current needed to run the cranking motor -- up to 500 amps -- to the cranking motor with as little voltage loss and in as short a time as possible.

1. The major components of a cranking system are the:

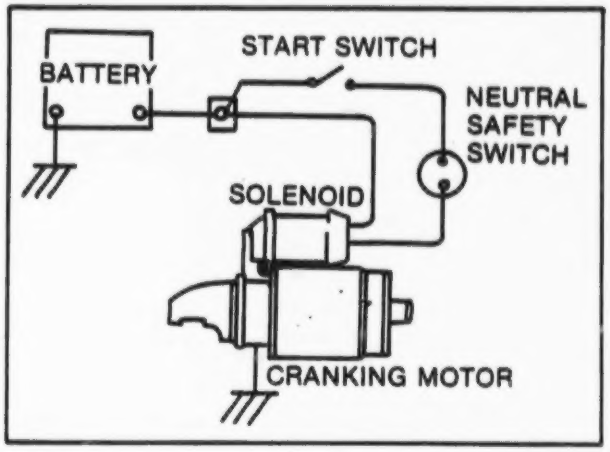
   - battery,
   - battery cables and wires,
   - neutral safety switch,
   - ignition switch,
   - electro-magnetic switch, and
   - starter motor.


POWER CIRCUIT
MAGNETIC SWITCH (RELAY OR SOLENOID)
BATTERY
IGNITION SWITCH
NEUTRAL SAFETY SWITCH
CONTROL CIRCUIT
STARTER MOTOR
FLYWHEEL

a. The **ignition switch** is usually a multiple-position switch that controls the ignition circuit, the electrical accessories and the cranking circuit.


IGNITION KEY
IGNITION SWITCH

b. The **neutral safety switch** is located on the transmission linkage or clutch linkage. The neutral safety switch is usually an open switch that prevents the engine from being cranked when in gear or when the clutch is not depressed.

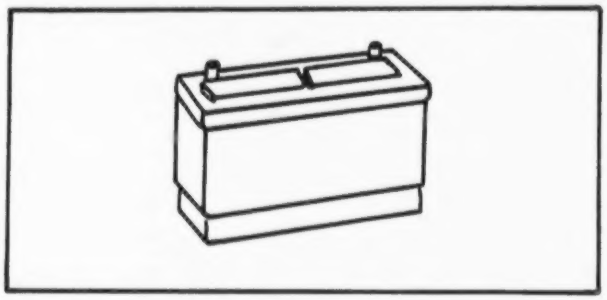

BATTERY
START SWITCH
NEUTRAL SAFETY SWITCH
SOLENOID
CRANKING MOTOR

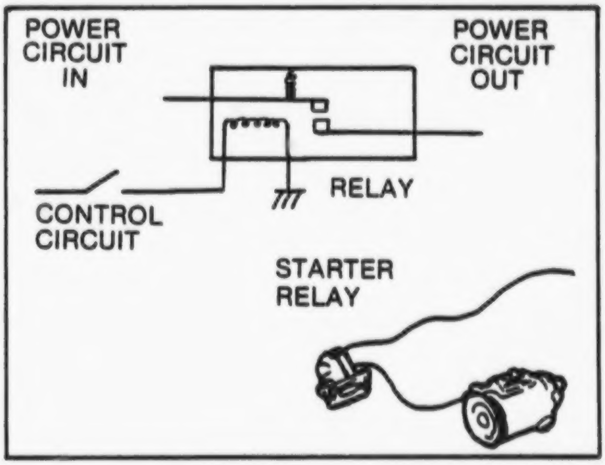
c. The **battery** is the power supply for the cranking circuit. To ensure that the cranking circuit can do its job, it is important to:

(1)have a battery that can produce enough energy to crank the engine,

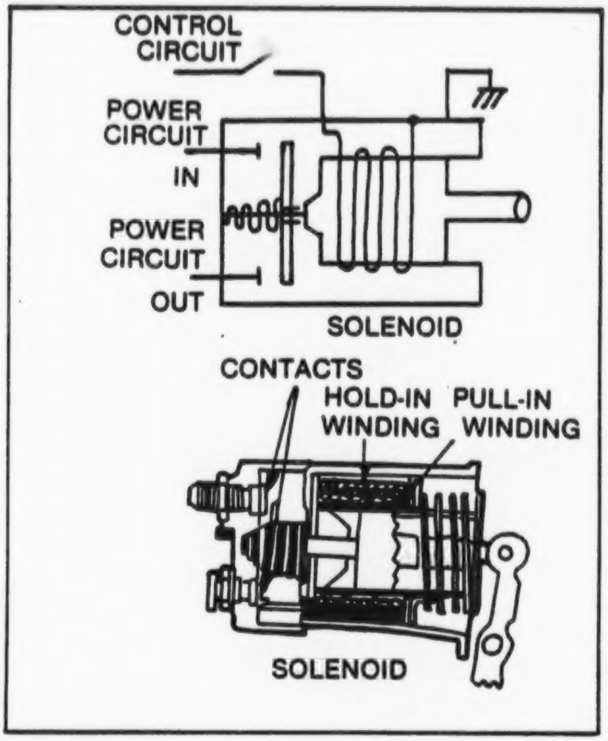
(2)keep the battery charged and

(3)keep the battery and posts clean.



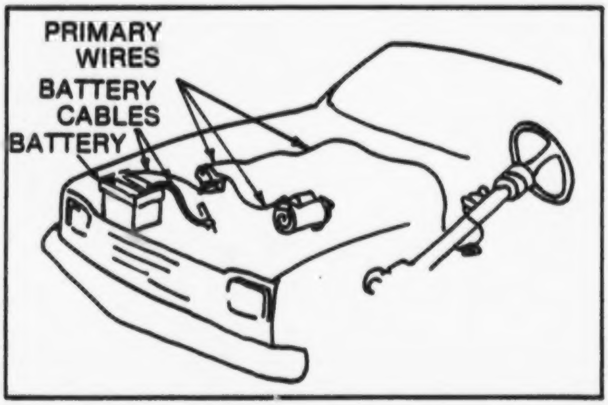

POWER CIRCUIT IN
POWER CIRCUIT OUT
RELAY
CONTROL CIRCUIT
STARTER RELAY

d. The **electro-magnetic switch** in the cranking circuit can be a relay or a solenoid. There are two types of switches -- relays and solenoids. (Technicians may interchange the terms, so be sure to know the type you're working on.)

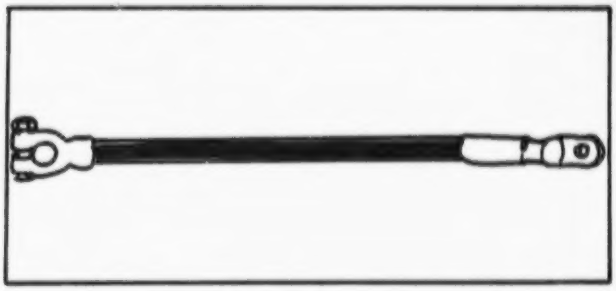

CONTROL CIRCUIT
POWER CIRCUIT IN
POWER CIRCUIT OUT
SOLENOID
CONTACTS
HOLD-IN WINDING
PULL-IN WINDING
SOLENOID

- A relay uses electro-magnetic action to close a set of contact points.

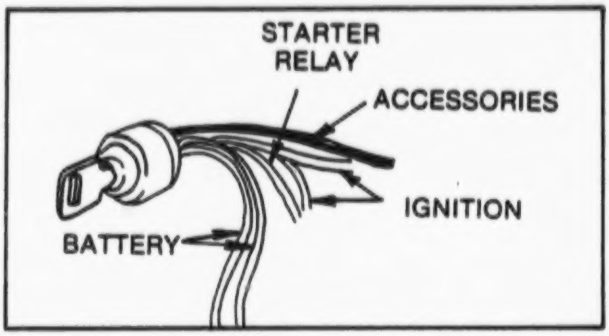
- A solenoid uses electro-magnetic action to engage the starter drive and flywheel. Engaging them closes a set of contact points.


PRIMARY WIRES
BATTERY CABLES
BATTERY

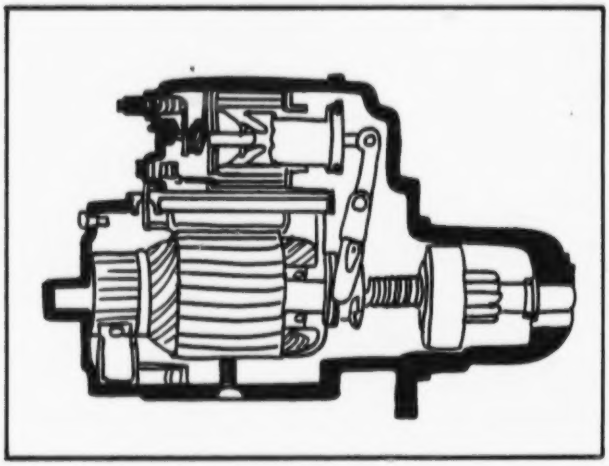
e. The **battery wires and cables** should be able to carry electric current without overheating, be in good shape and be firmly attached to the terminals.



The term "cable" usually means the larger wiring used to carry current to the cranking motor. There are usually two cables: a positive (red) and a negative (black) cable.



The term "wire" usually means the smaller wiring used to control the electro-magnetic switch.



f. The **starter motor** is a small but powerful direct current electric motor whose only function is to crank the engine fast enough to start it.

The cranking motor is the largest user of battery current and can use up much of the battery's potential in a short amount of time if the engine is cranked too long. Most manufacturers suggest cranking periods of 30 seconds or less with equal cool-down periods.

DO SKILL SHEET 1

SKILL SHEET 1

Directions: Complete the following statement with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

control
one minute
relay
thirty seconds
ignition switch
power
solenoid
neutral safety switch
rotate
start

1. The job of the cranking circuit is to ____________________ the engine.

2. The ____________________ circuit carries only a small amount of current to control the magnetic switch.

3. To prevent the engine from starting in "drive," a ______________ is used.

4. The ______________________ is a type of electromagnetic switch that engages the starter drive with the flywheel -- and then closes a set of contact points.

5. To protect the starter from damage, most manufacturers recommend cranking periods of not more than _________ .

C. **There are four common complaints about the cranking system.**

The procedure you use will depend on which of the four complaints you hear:

(1) "The starter spins, but the engine will not crank."

(2) "The engine is cranking too slowly."

(3) "The engine will not crank."

(4) "The starter's too noisy when the engine is cranking."

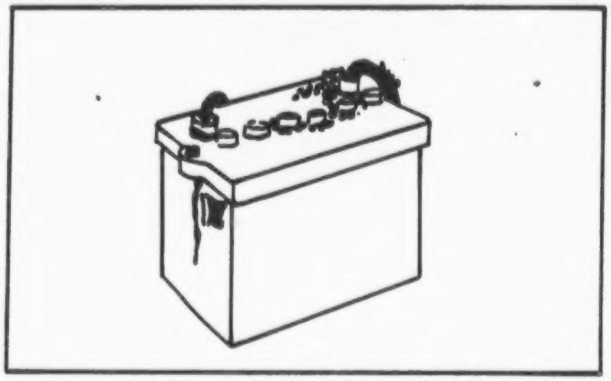
D. Cranking Circuit Inspection

Several of the problems that come from the cranking system can be found by carefully looking at all components in the cranking circuit. A careful inspection will include looking at the:

Battery,
Wires and cables,
Switches,
Electromagnetic switches, and
Cranking motor.

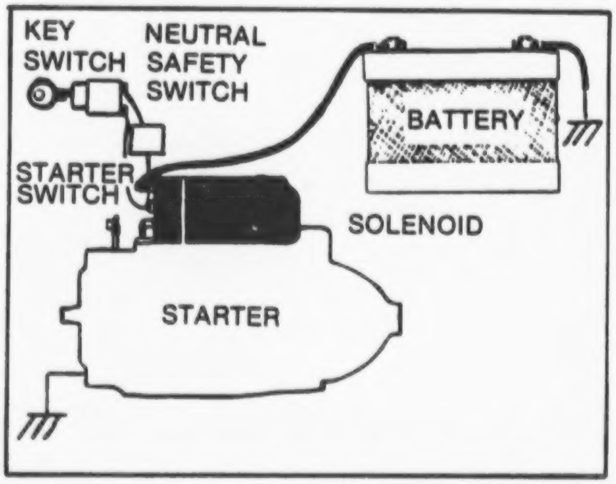
a. Check the battery for:

Loose or corroded terminals
Loose or corroded ground cable connections
Frayed cables
Damaged insulation



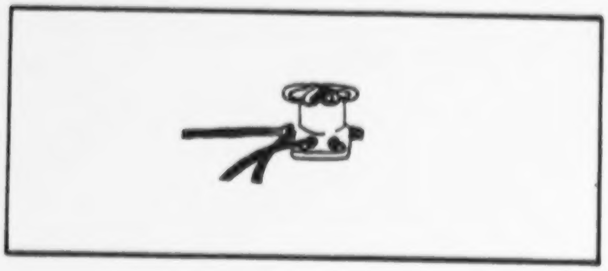
b. Check the switches in the control circuit for:

Loose mounting
Sticking contacts
Damaged wiring
Loose connections
Poor adjustment
Loose or damaged wiring


KEY SWITCH
NEUTRAL SAFETY SWITCH
BATTERY
STARTER SWITCH
SOLENOID
STARTER

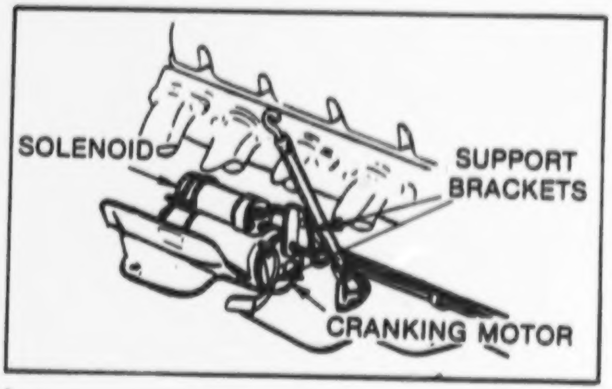
c. Check the electromagnetic switch for:

Loose mounting
Loose connections
Damaged wiring



d. Check the cranking motor for:

Loose mounting
Poor pinion adjustment
Loose wiring and connections
Damaged wiring and connections


SOLENOID
SUPPORT BRACKETS
CRANKING MOTOR

E. When the starter spins but does not crank the engine, try the "starter drive test."

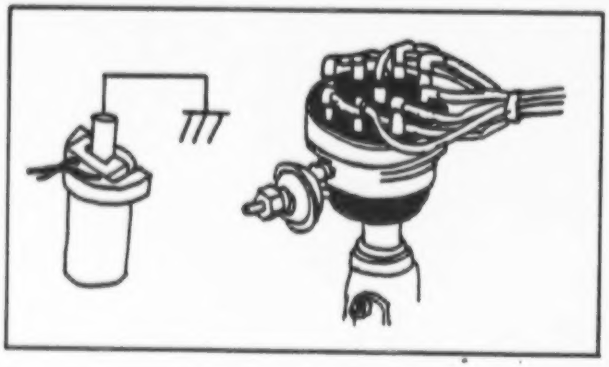
The purpose of this test is to diagnose a slipping starter drive problem without removing the starter from the car.

1. Do the following:

   a. To prevent the engine from starting, disconnect and ground the coil wire at the distributor cap.

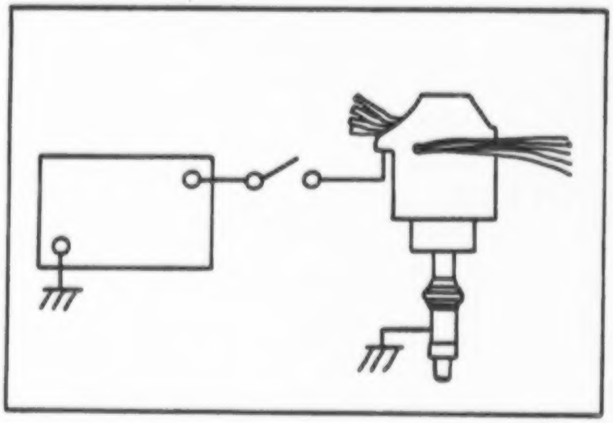
   OR:

   Disconnect the 12-volt power wire that goes to the coil.

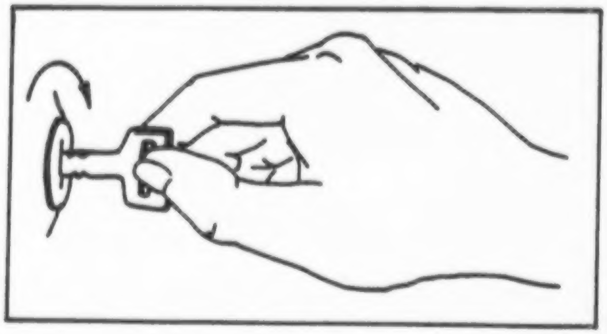


CAUTION: On automatic transmission cars, make sure the shift lever is in the "park" (P) position and the emergency brake is on.

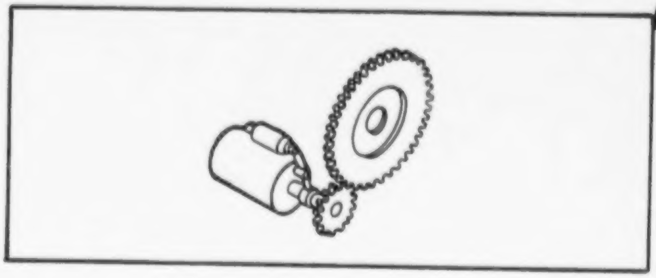
On manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.



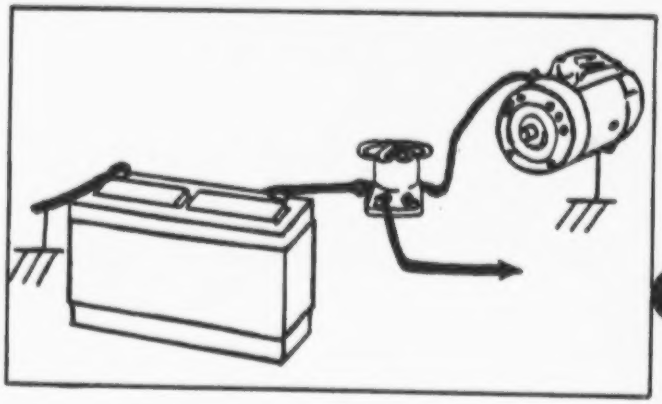
   b. Turn the ignition key to "start" and hold it in the start position for 30 seconds.



c. The starter drive should continue to crank the engine. If it continues to crank, the starter drive is O.K.



d. If the engine stops turning and the starter spins noisily at high speed, release the key. The drive is slipping and should be replaced.



e. Repeat the test at least three times to detect an intermittent condition.

f. Record your results.

g. Discuss the results with your instructor and decide the best action to take.

h. Put away your equipment and clean up the work area.

DO ACTIVITY SHEET 1

STARTER DRIVE TEST

ACTIVITY SHEET 1

1. See your instructor to get a car that needs its cranking system tested.

2. Review the the starter drive test procedure given in this unit and in the proper service manual.

3. Get the needed tools and equipment.

4. Complete the testing procedure. WEAR SAFETY GLASSES!

5. Record your results.

____

____

____

____

____

____

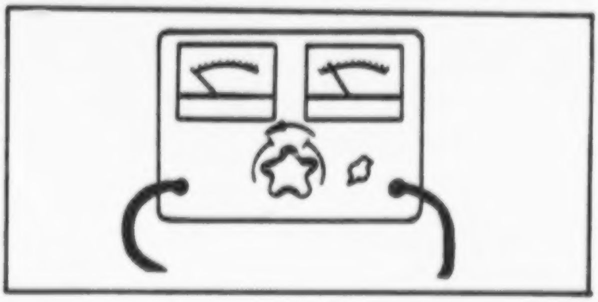
____

6. Discuss the results with your teacher and decide the best action to take.

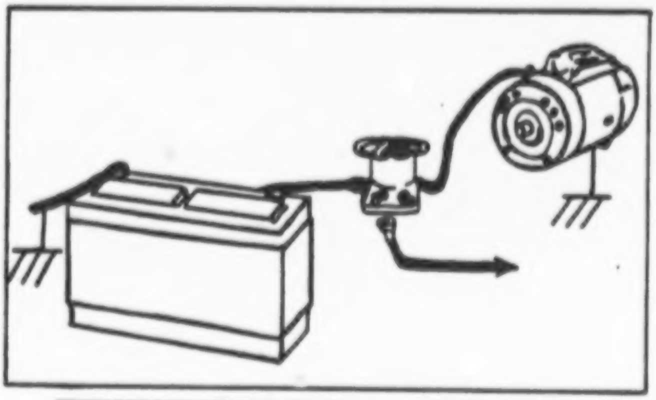
7. Put away your tools and clean up the work area.

F. When the engine cranks slowly, try the "cranking motor load test" and voltage drop tests on the "ground," "positive" and "switch" circuits.

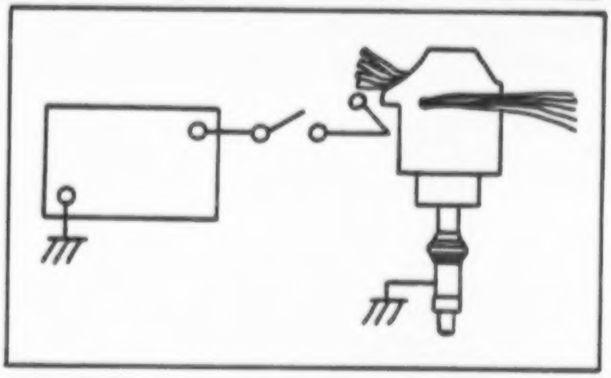
1. Begin the cranking motor load test by making sure the load control knob of the Battery-Starter Tester is turned "off." (The knob should be at the maximum counter-clockwise position.)



2. Disconnect the ignition bypass lead at the relay (or solenoid) terminal to prevent the engine from starting.

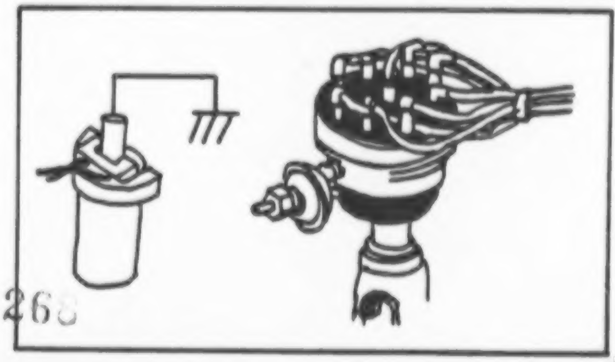


3. To further prevent engine starts, disconnect the coil at the distributor and ground it.

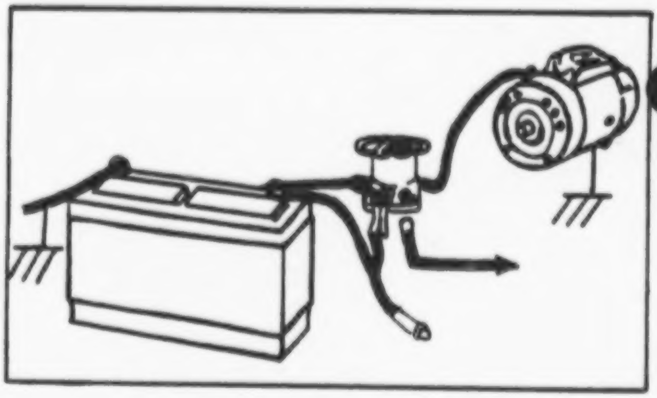


OR:

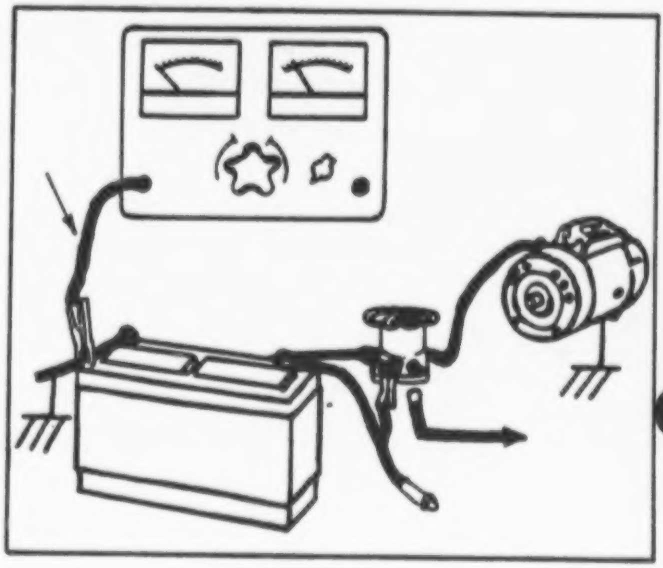
Disconnect the 12-volt power wire that goes to the coil.



4. Install a remote control starter switch between the battery's positive terminal and the starter relay's (or solenoid's) Switch or "S" terminal.



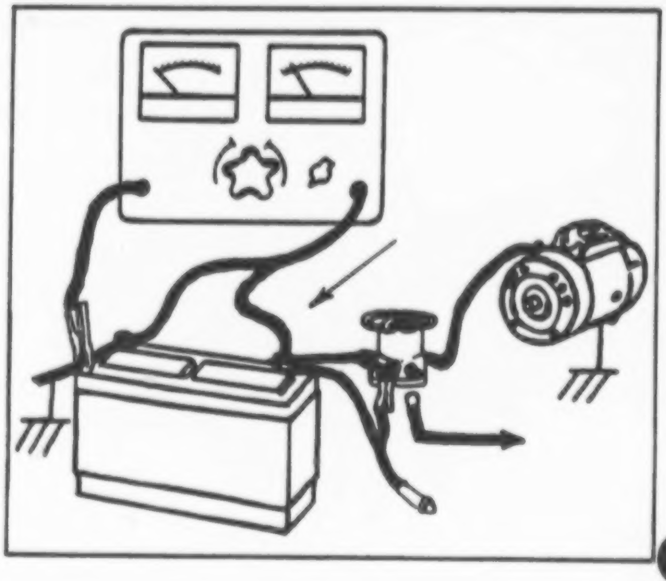
5. Place the inductive pick-up clamp around the negative battery cable. If the battery has two or more negative battery cables, the cables should be placed inside the inductive pick-up.



6. Connect the voltmeter test leads to the battery terminals. Red should be attached to positive, and black should be attached to negative.

7. Make sure the battery is properly charged.

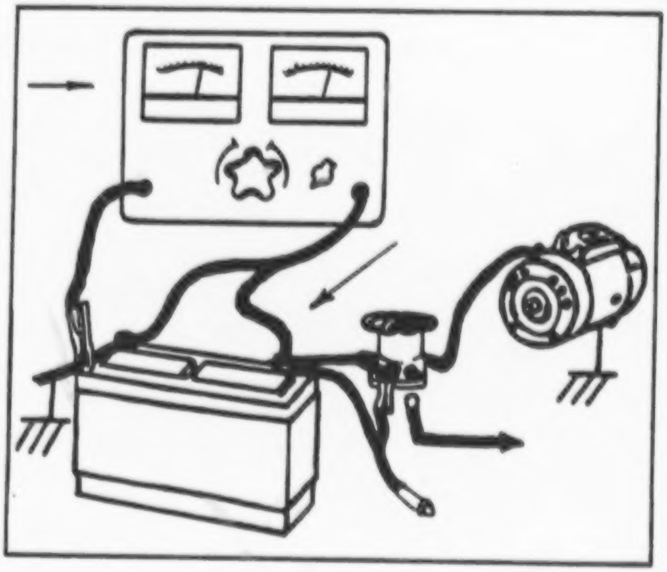
NOTE: Battery testing is not covered in this unit. See your instructor for more information.



8. Using the remote control starter switch, crank the engine until the needles stabilize.

9. Read the ammeter and voltmeter.

CAUTION: On automatic transmission cars, make sure the shift lever is in "park" (P) and the emergency brake is on. On manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.



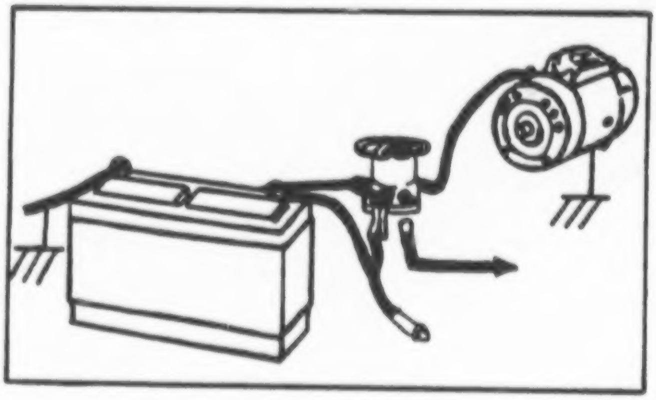
10. Record your results.

11. The expected test results are:

Engine	Amps	Volts
Eight cylinders	200-250	9.6-10.2
Six cylinders	150-175	9.6-10.2
Four cylinders	125-150	9.6-10.2

The expected test results may vary depending on (1)engine condition, (2)temperature, (3) state of battery charge and (4)cranking motor condition.

12. You begin the next test, the ground circuit voltage test, by disconnecting the ignition bypass lead at the relay (or solenoid) terminal to prevent the engine from starting.

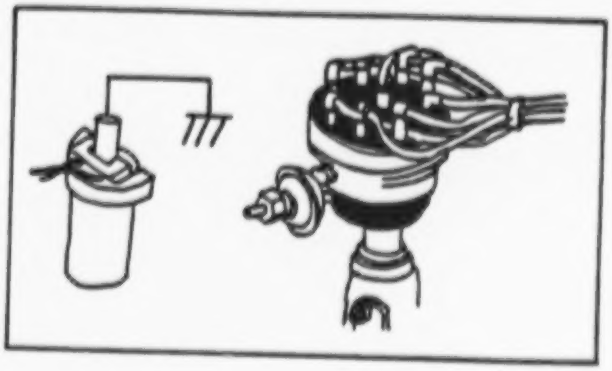


270

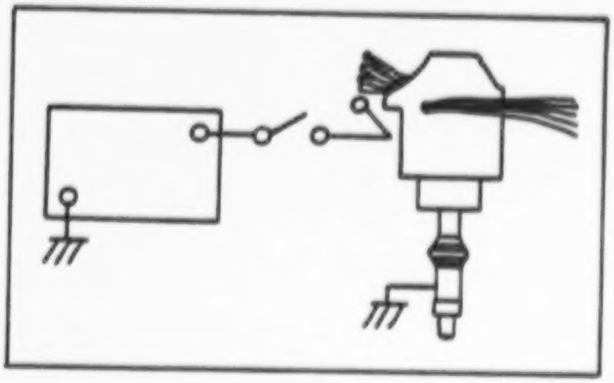
13. To further prevent engine starts, disconnect the coil at the distributor and ground it.

    OR:

    Disconnect the 12-volt power wire that goes to the coil.

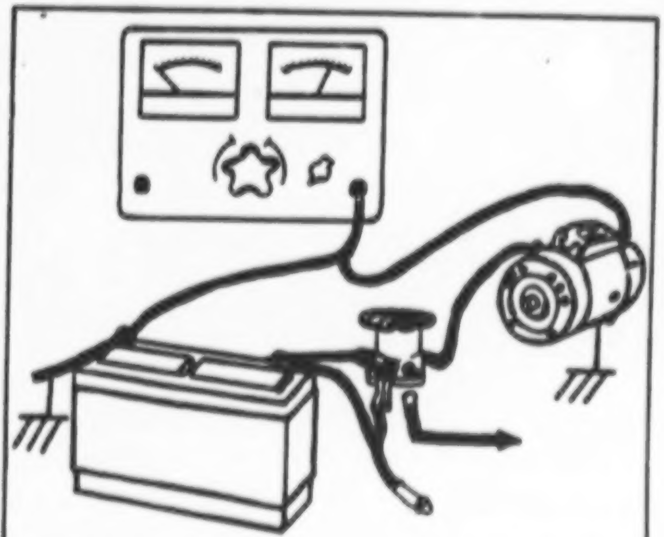


14. Connect the negative lead to the battery's negative (-) terminal and the positive lead to the engine ground.



15. Set the voltmeter to its lowest scale.

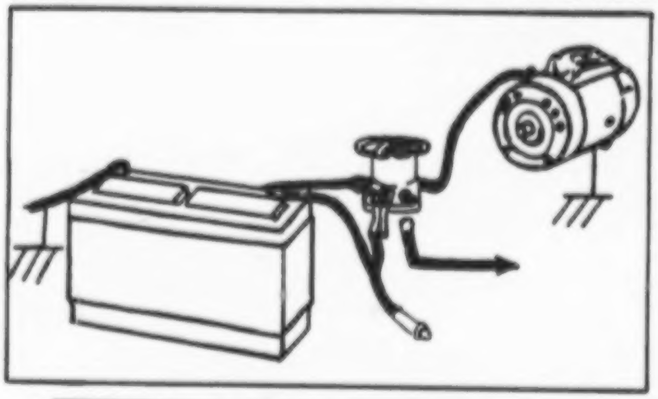
16. Using the remote control starter switch, crank the engine until the needle stabilizes. Read the voltmeter.



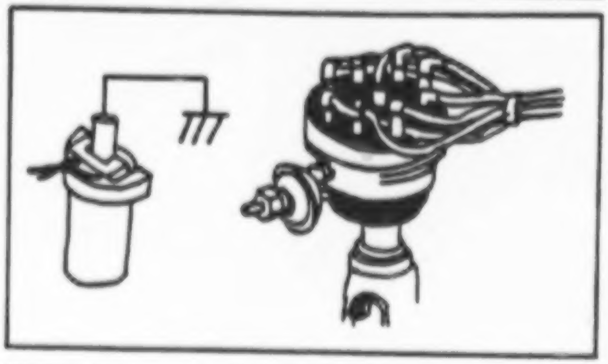
CAUTION: On automatic transmission cars, make sure the shift lever is in "park" (P) and the emergency brake is on. On manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.

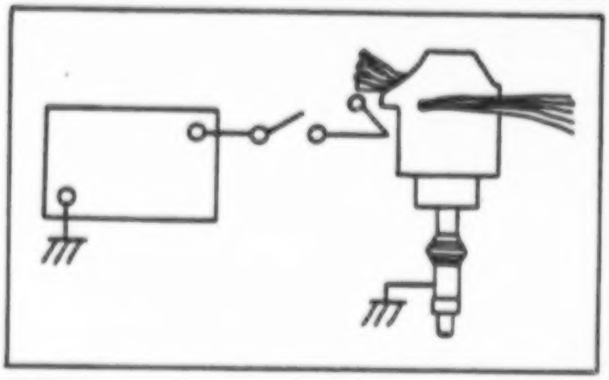
The reading on the voltmeter should be no more than 0.2 volts.

17. Record your results.



18. To begin the next test, the positive circuit voltage drop test, disconnect the ignition bypass lead at the relay (or solenoid) terminal to prevent the engine from starting.

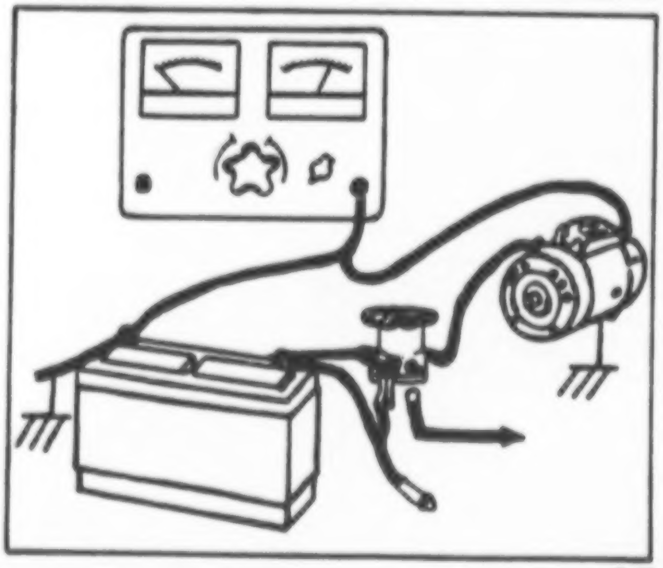




19. To further prevent engine starts, disconnect the coil at the distributor and ground it.

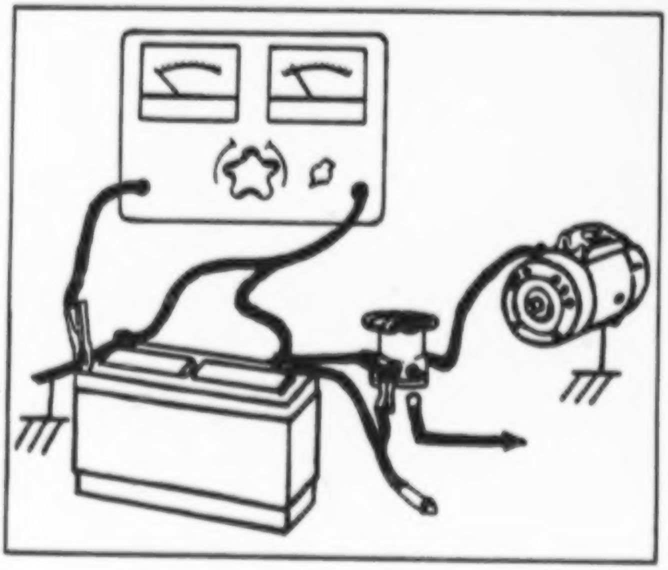
OR:

Disconnect the 12-volt power wire going to the coil.



20. Connect the positive lead to the battery's positive (+) terminal and the negative lead to the starter's "Bat" terminal.

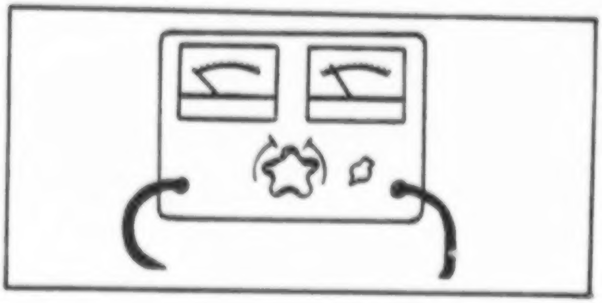
21. Using the remote control starter switch, crank the engine and adjust the voltmeter to its lowest range.



CAUTION: On automatic transmission cars, make sure the shift lever is in "park" (P) and the emergency brake is on. On manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.

22. Continue to crank the engine until the needle stabilizes and read the voltmeter.

    It should register no more than 0.5 volts.



23. Adjust the voltmeter to a higher range and stop cranking.

24. Record your results.

25. Put away your equipment and clean up the work area.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

SKILL SHEET 2

Directions: Complete the following statement with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

1. The battery (should, should not) be fully charged before doing the cranking circuit test.

2. The inductive ammeter lead usually goes around the (positive, negative) battery cable.

3. Complete the chart below.

   Cranking motor load test expected results:

Engine	Amps	Volts
Eight cylinder	_____	_____
Six cylinder	_____	_____
Four cylinder	_____	_____

4. Complete the chart below.

   Voltage drop tests expected results:

   Positive circuit test maximum voltage drop _____
   Negative circuit test maximum voltage drop _____
   Switch circuit test maximum voltage drop _____

TESTING THE STARTER CIRCUIT

ACTIVITY SHEET 2

1. See your instructor to get a car that needs its starter circuit tested.

   Number of cylinders in the engine ________

2. Review the procedure outlined in this unit and the proper service manual for the cranking motor load test and voltage drop test.

   NOTE: Service manuals may give you a specific procedure or method that will make the job less difficult.

3. Get the needed tools and equipment.

4. Complete the service procedure. WEAR SAFETY GLASSES!

5. The state of charge in the battery is
   O.K. Not O.K.
   If your answer is "Not O.K.," recharge or replace the battery.

6. Starter motor load test:

Specifications	Results
volts ____	volts ____
amps ____	amps ____
O.K. ☐	Not O.K. ☐

7. Ground circuit voltage drop test:

Specifications	Results
volts ____	volts ____
O.K. ☐	O.K. ☐

8. Positive circuit voltage drop test:

Specifications	Results
volts ____	volts ____
O.K. ☐	Not O.K. ☐

9. Switch circuit voltage drop test:

Specifications	Results
volts ____	volts ____
O.K. ☐	Not O.K. ☐

10. Discuss results with your instructor and decide the best action to take.

11. Put away your tools and clean up the work area.

G. When the engine will not crank:

There are several possible causes for this problem. If the battery checks out and has been eliminated as a possible cause:

(1) the battery power is being prevented from reaching the starter motor

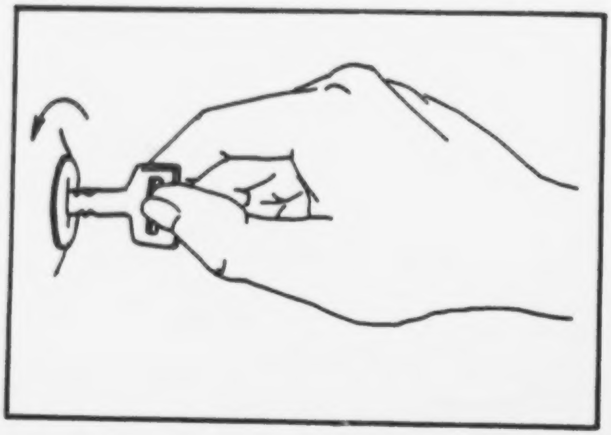
OR:

(2) the motor is defective and must be repaired or replaced.

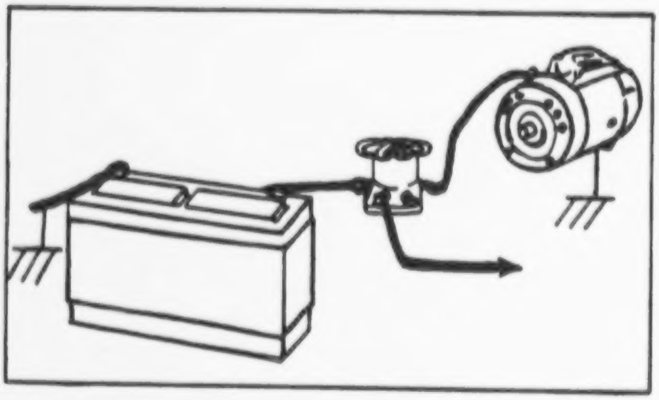
1. Begin tracking the problem with the starting control circuit test.

   The purpose of this test is to see if the engine is failing to crank because of open circuits, defective wiring or poor connections. Each of these problems can create too much resistance in the starter control circuit.

2. Make sure the ignition switch is OFF.



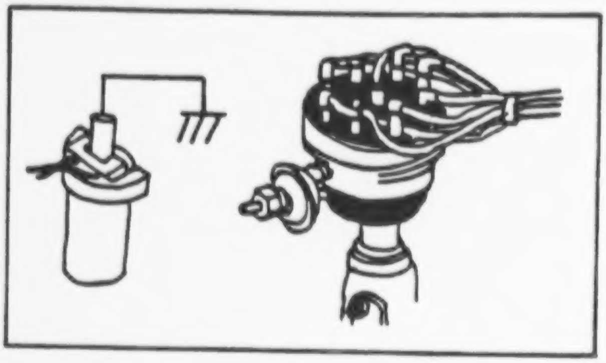
3. Disconnect the ignition bypass lead at the relay (or solenoid) to prevent the engine from starting.



4. To further prevent the engine from starting, disconnect and ground the coil wire at the distributor cap.

   Or:

   Disconnect the 12-volt power wire that goes to the coil.

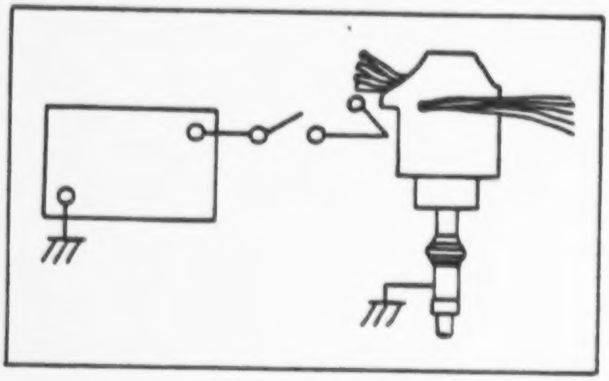


CAUTION: On automatic transmission cars, make sure the shift lever is in "park" (P) and the emergency brake is on. On manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.

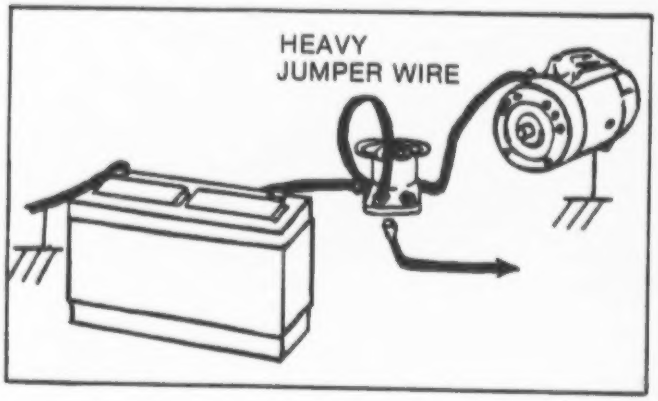
5. Test the starting switch circuit with a bypass test.

   (NOTE: The same procedure would be used to test a circuit that uses a solenoid.)

   This test is a small part of the starting control circuit test. Its purpose is to check the starter (ignition) switch circuit, including the neutral safety switch.



a. Connect a jumper wire from the battery's positive terminal to the starter relay's "S" terminal. Try to crank the engine now.



CAUTION: Use 10-gauge wire or heavier.

b. Record your results.

- If the engine still won't crank, check all cables and connections, including the relay ground connection and go to step six.

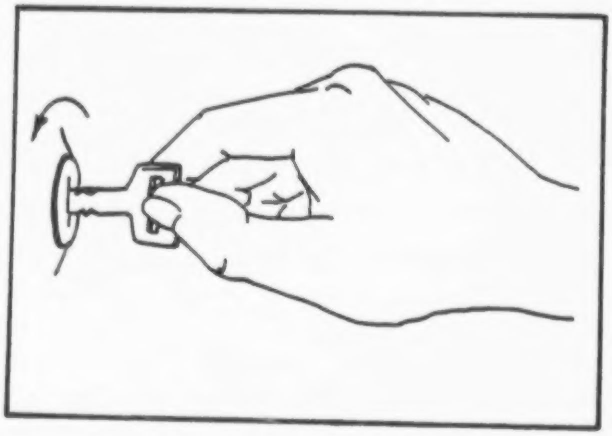
- If the engine cranks, check the starter (ignition) switch circuit and the neutral start switch circuit.

c. Put away your equipment and clean up the work area.

6. If the engine still will not crank, try the relay bypass test.

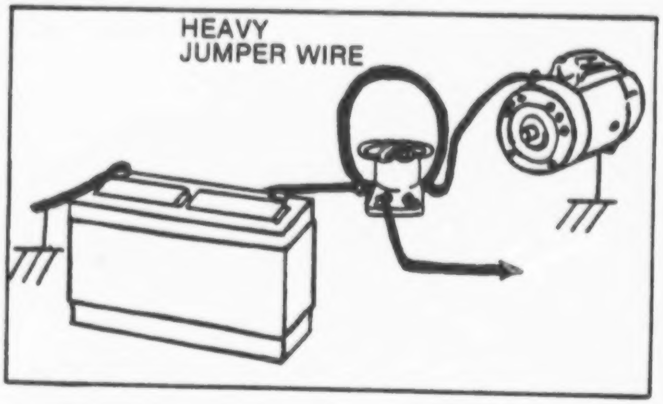
(NOTE: The same procedure would be used to test a solenoid.)

The purpose of this test is to see if the starter relay is defective.



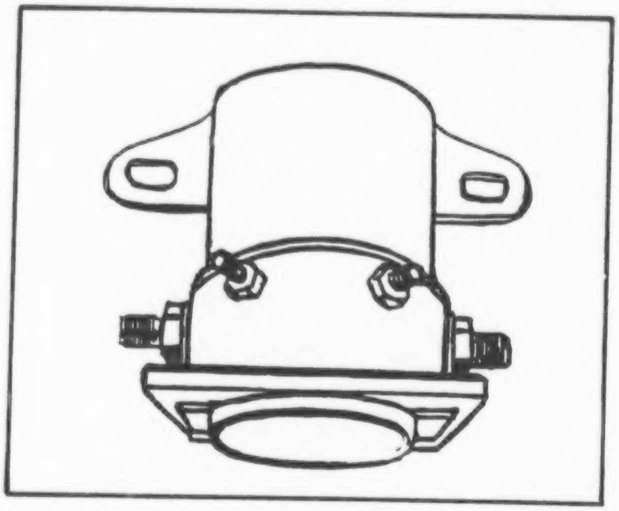
a. Make sure the ignition switch is OFF so the engine will not start on you.

b. Connect the heavy jumper cable from the battery's positive terminal and hold it against the starter relay's "Starter" terminal.



CAUTION: Use 4-gauge wire or heavier.

c. Record your results.



- If the engine cranks now, the starter relay is defective and should be replaced.

d. Put away your equipment and clean up the work area.

DO ACTIVITY SHEET 3

TESTING THE STARTER CIRCUIT

ACTIVITY SHEET 3

1. See your instructor to get a car that needs its starter system checked.

2. Review the procedure outlined in this unit and the proper service manual that tells what to do when an engine won't crank.

3. Get the needed tools and equipment.

4. Complete the inspection procedure. WEAR SAFETY GLASSES!

5. Record your results.

   switch circuit bypass test:

   ____

   ____

   ____

   relay bypass test:

   ____

   ____

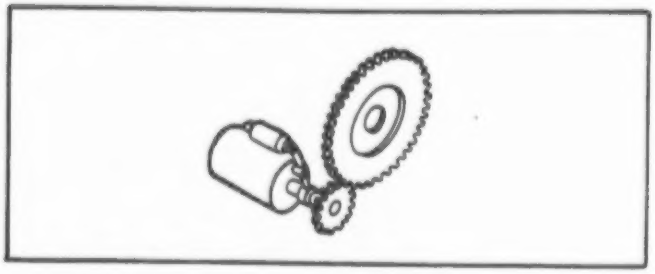
   ____

6. Discuss the results with your instructor and decide on the proper action to take.

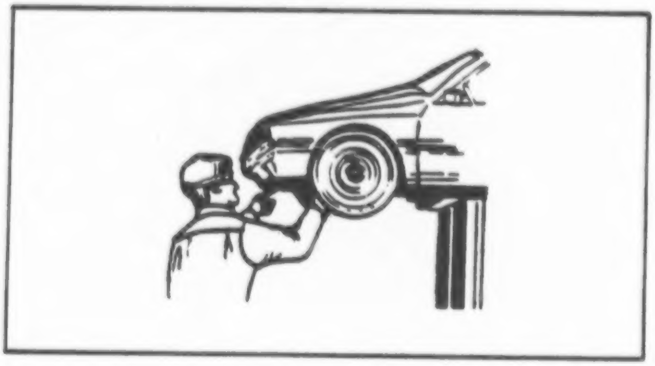
7. Put away your tools and clean up the work area.

H. When starter cranking is noisy, perform the following test:

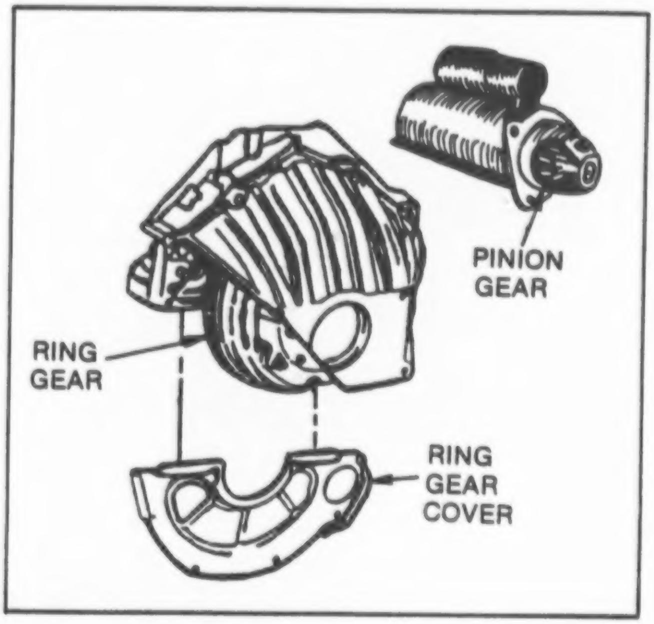
Unusually noisy starter cranking can mean the pinion-to-ring gear teeth are not engaging each other properly.



Such problems are caused by an improper, loose or misaligned starter mounting or by an improper flywheel ring gear or flex plate location.

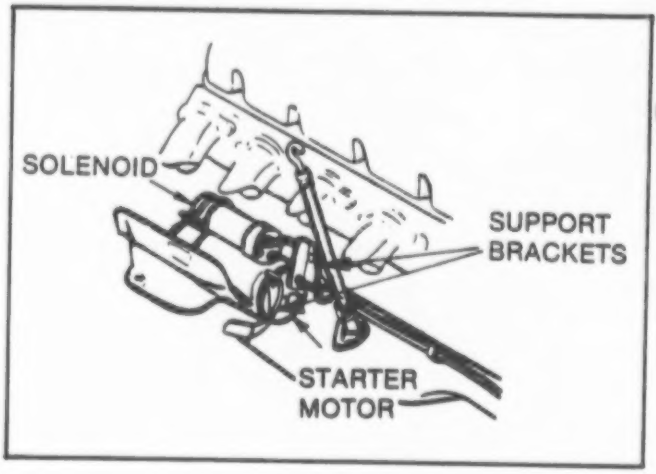


1. Place the car securely on jack stands or lift it with a hoist.



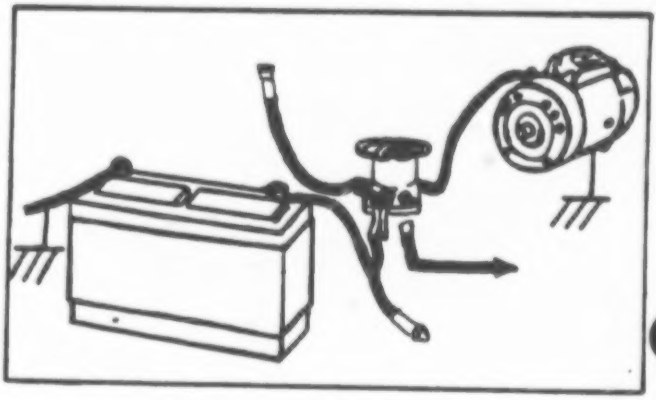
2. Remove the ring gear cover and inspect the pinion and ring gear tooth wear patterns.
3. Check the starter mounting bolts.
4. Torque the bolts to specification. (See the service manual.)

5. Make sure the rear mounting bracket is tight. (See service manual to see if one is required.)


SOLENOID
SUPPORT BRACKETS
STARTER MOTOR

6. Check the gear tooth clearance between the flywheel teeth and the starter drive pinion teeth.

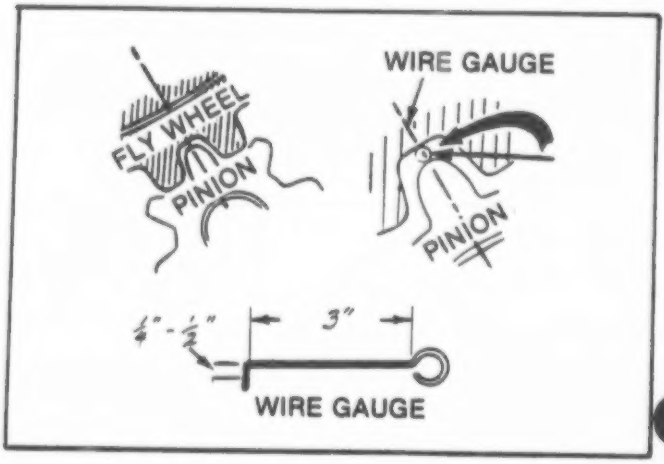
   a. Remove the negative battery terminal, and then remove the positive battery terminal.



   b. Install a remote control starter switch between the battery positive terminal and the starter relay's (or solenoid's) switch ("S") terminal.

   c. Install the negative battery terminal.

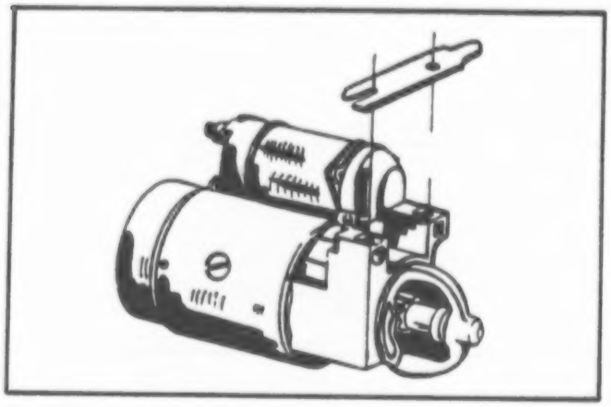
   d. Using the remote control starter switch, engage the starter pinion gear with the flywheel gear.


FLY WHEEL
PINION
WIRE GAUGE
PINION
1/4"-1/2"
3"
WIRE GAUGE

   e. Using a small wire gauge, measure the clearance between the starter pinion gear and the flywheel gear.

f. Record your results.

- If the clearance is too large, examine the ring gear or starter drive pinion for wear.



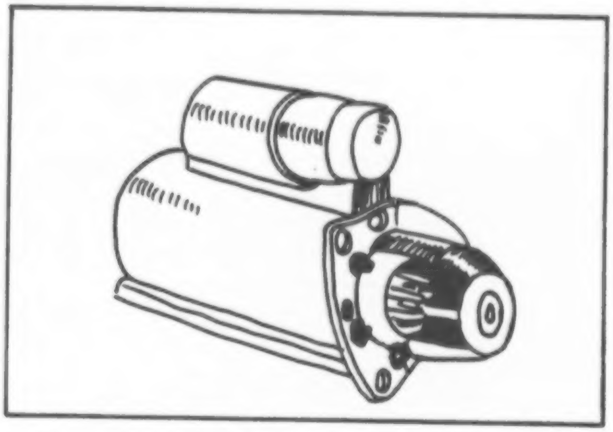
- If the clearance is not large enough, install a shim between the starter motor and mounting surface on the engine block.

- If the clearance is O.K.:

(1)check the alignment of the starter motor

(2)check the starter motor to be sure it rotates freely

(3)the starter motor may have an internal problem, such as a worn bearing, a bent shaft or a dragging pole shoe.



If so, you must repair or replace the starter motor.

7. Remove the remote control starter switch.

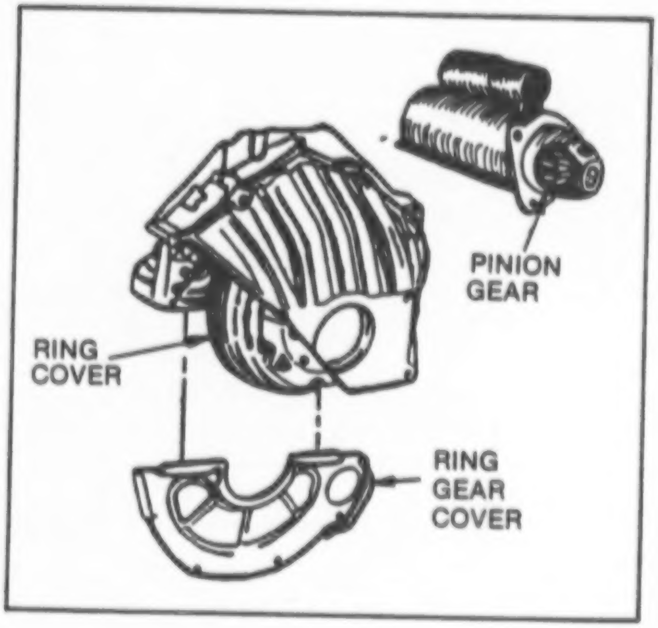
8. Install the ring gear inspection cover.

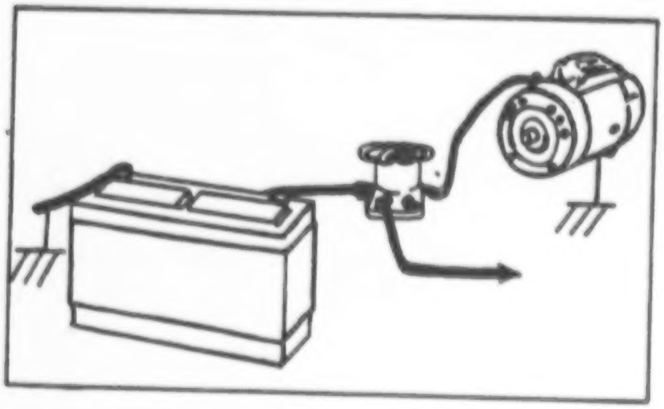
9. Remove the negative battery terminal.

10. Install the positive battery terminal, and then install the negative battery terminal.

11. Put away your equipment and clean up the work area.

DO ACTIVITY SHEET 4


PINION GEAR
RING COVER
RING GEAR COVER



CHECKING THE STARTER MOUNTING AND PINION GEAR TEETH

ACTIVITY SHEET 4

1. See your instructor to get a car that needs its starter system checked.

2. Review the procedure outlined in this unit and the proper service manual.

3. Get the needed tools and equipment.

4. Complete the inspection procedure. WEAR SAFETY GLASSES!

5. Record your results.

Starter mounting bolts
Torque specification __________
O.K. ☐ Not O.K. ☐

Rear mounting bracket
O.K. ☐ Not O.K. ☐

Gear tooth clearance
Specification __________
O.K. ☐ Not O.K. ☐

6. Discuss results with your instructor and decide the proper action to take.

7. Put away your tools and clean up the work area.

TESTING THE CRANKING SYSTEM OF THE AUTOMOBILE

UNIT REVIEW

1. The maximum recommended cranking period is about 30 seconds.
   TRUE FALSE

2. How many amps does a four cylinder engine need to crank the engine.
   a. 125 to 150 b. 150 to 175
   c. 200 to 250 d. 300 to 350

3. The voltage drop result for the negative (ground) circuit should not exceed how many volts?

   a. 0.2 volts b. 0.3 volts
   c. 0.5 volts d. 1.0 volts

4. After completion of the switch circuit bypass test, the engine will not crank. Which of the following parts could not be the cause of the problem?

   a. battery b. cranking motor
   c. switch circuit d. relay or solenoid

5. A noisy starter could be caused by

   a. a misaligned starter. b. a bent armature shaft.
   c. worn ring gear teeth. d. all of the above

TESTING THE CRANKING SYSTEM OF THE AUTOMOBILE

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Put on his/her safety glasses			
2. Gathered necessary tools and equipment			
3. Used a volt-ohmmeter correctly			
4. Performed a starter drive test			
5. Inspected starter drive components			
6. Performed a starter cranking circuit test			
7. Performed a starting motor load test			
8. Performed a starter control circuit test			
9. Performed a starter relay bypass test			
10. Performed a starter no-load test			
11. Performed an armature open circuit test			
12. Performed an armature and field grounded circuit test			
13. Performed test for noisy starter cranking			

Should move on ☐

Should repeat this unit ☐

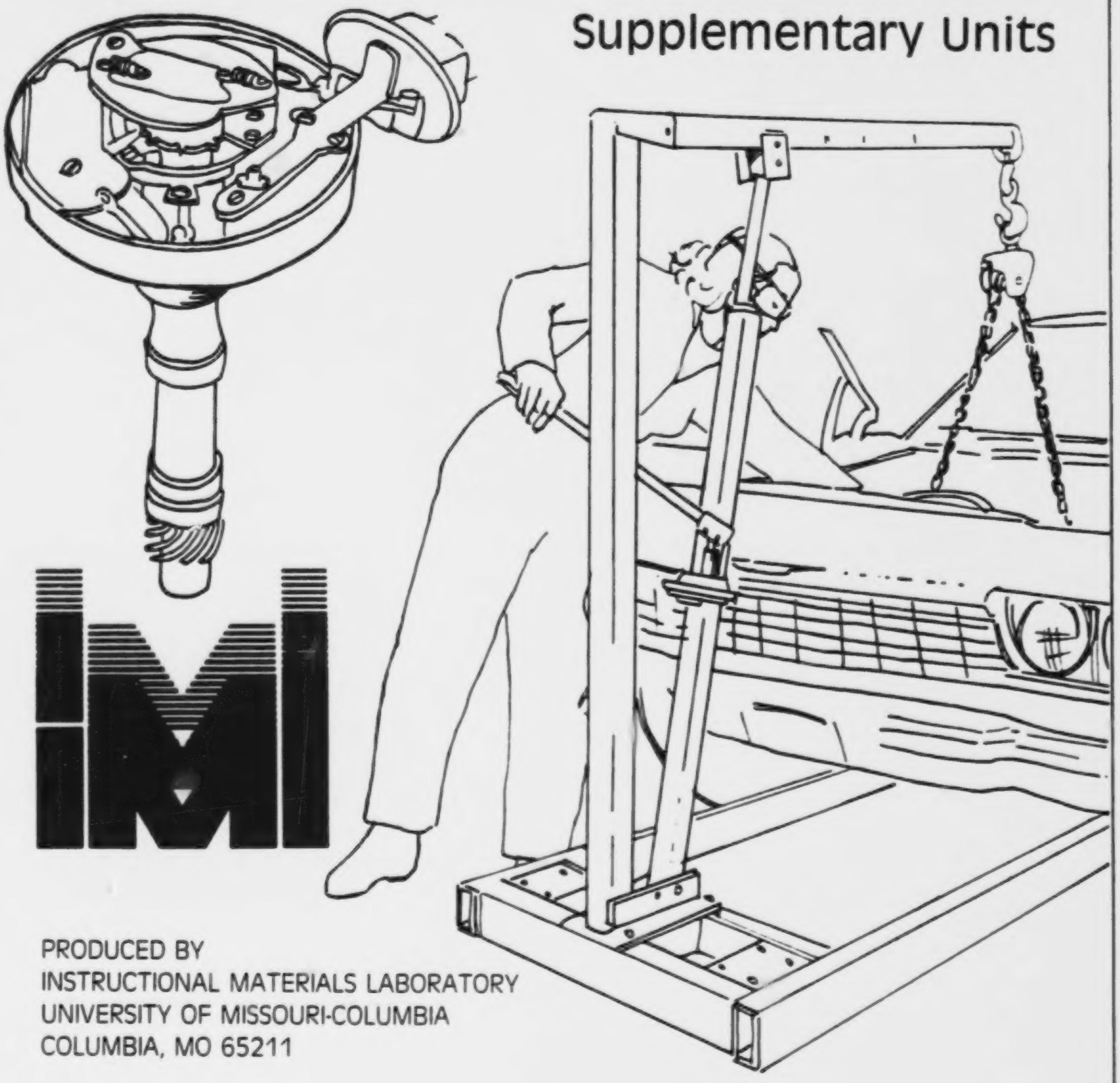
____
Student's Signature/Date

____
Instructor's Signature/Date

90-6020-S

Auto Mechanics

Supplementary Units



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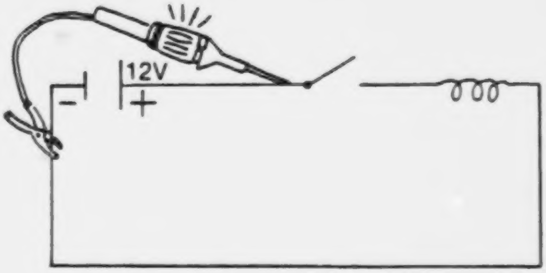
UNIVERSITY OF MISSOURI-COLUMBIA
COLUMBIA, MO 65211



Unit 10

Trouble-shooting an Electronic Ignition System

FUNDED BY DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MO 65102

TROUBLE-SHOOTING AN ELECTRONIC IGNITION SYSTEM

INTRODUCTION

The automotive industry developed the electronic ignition to meet the demands for greater emission control in the 1970s. Emission control brought leaner fuel mixtures, wider spark plug gaps and longer service intervals.

While the Electronic Ignition System can supply 35,000 volts to the spark plugs, it has also complicated the under-the-hood wiring of the ignition system. This unit explains the basic steps in testing electronic ignition systems.

UNIT OBJECTIVES

After completing this unit, you will be able to describe how an electronic ignition system operates and perform basic trouble-shooting procedures.

SPECIFIC OBJECTIVES

After completing this unit, you will be able to specifically:

1. List the major components of an electronic ignition system.
2. Describe how an electronic ignition system works.
3. Name the two most common complaints that indicate problems in the ignition system.
4. Use proper electronic ignition trouble-shooting procedures to perform tests and repairs.
5. Use an ohmmeter.
6. Use a voltmeter.

Check the statement that fits you best.

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms

1. **Centrifugal advance** - a device found on cars that advances or delays the ignition spark to correspond with changes in engine speed.

2. **Coil** - the part in the ignition system that receives a small amount of electrical voltage from the battery, increases this voltage into a big jolt of electricity and sends it to the spark plugs.

3. **Distributor cap** - a cover that protects the distributor from dirt and moisture. The cap has a tower for each spark plug cable and one for the wire from the coil.

4. **Electronic ignition** - an ignition system in which the distributor sends electrical current to the spark plugs by electronic means.

5. **Module** - a compact assembly (small set of parts fitted together) that is part of a larger electronic unit.

6. **Pick-up coil** - a small device, in a high energy ignition system, responsible for generating a magnetic field that induces a voltage to be sent into the ignition coil.

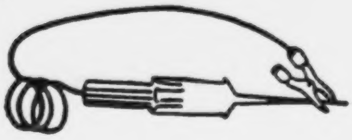
7. **Rotor** - a device on top of the distributor shaft that conducts electric current to each spark plug in turn.

8. **Spark plug** - a device that delivers the electrical spark that ignites the fuel/air mixture in the combustion chamber.

9. **Vacuum advance** - a unit designed to advance or delay the ignition spark in response to the vacuum produced by operation of the engine at the required load.

Equipment

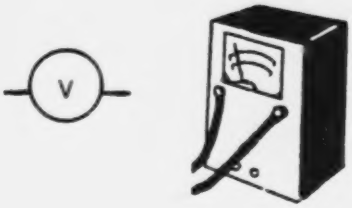
Test light



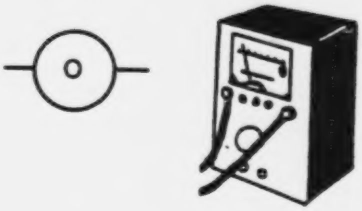
Specification manual

CHILTON'S
AUTO
MANUAL
VOLVO
DATSUN
MANUAL

Voltmeter

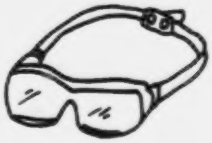


Ohmmeter



Hand tools

Safety glasses

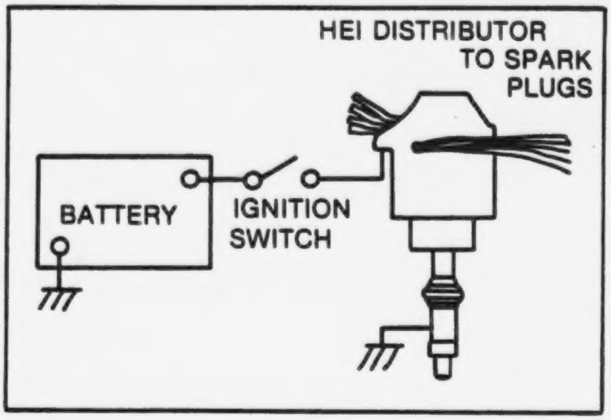


B. How an Electronic Ignition System Works

(Because of space and time limitations, the information given is for General Motors cars with an HEI--High Energy Ignition--system. The HEI system's coil is located in the top of the distributor cap.

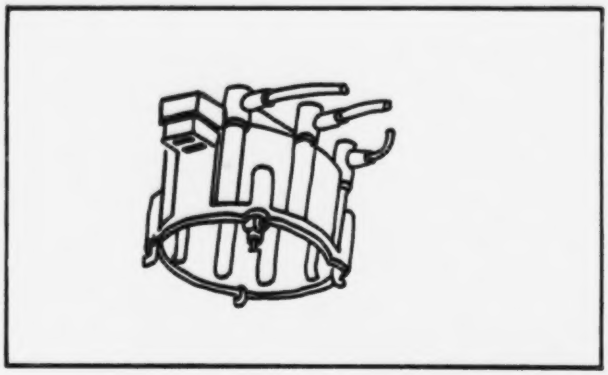
Most parts in the HEI system work like those on non-GM cars. Although the parts in each car maker's electronic ignition system will vary in size and appearance, the test procedure should be the same. Your instructor will give you information about other makes.)

1. Ignition systems must deliver voltage to the spark plugs at the right time and place.



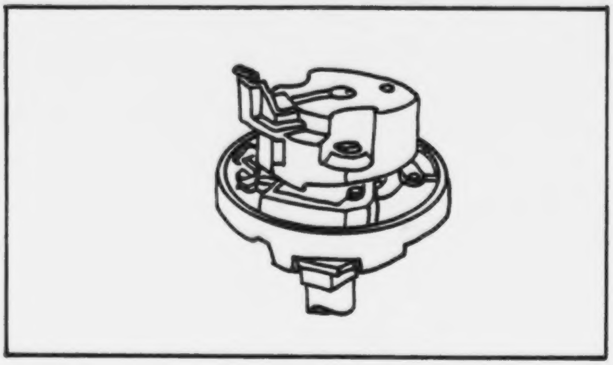
2. The electronic ignition is a complete system. Battery voltage is all the system needs to work. In this HEI system, all components are in the distributor and its cap.

3. Some HEI systems, from other car makers or from GM, have components that are separate from each other.

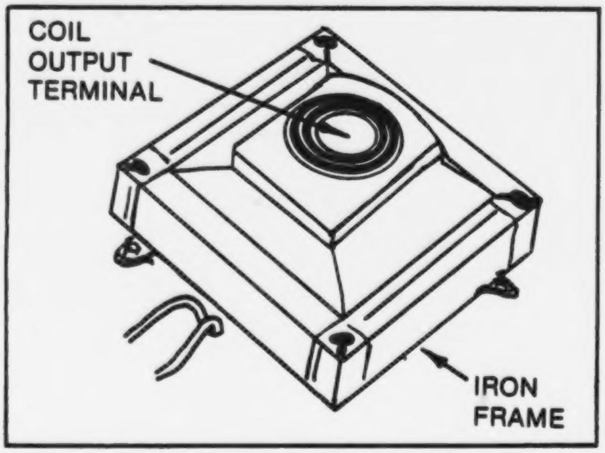


4. The large size of the electronic ignition cap prevents voltage arc-over and allows room for the ignition coil.

5. The lower housing contains the gear-driven timer core shaft, the rotor, the centrifugal advance mechanism, the pick-up coil assembly, the electronic module and the vacuum advance.



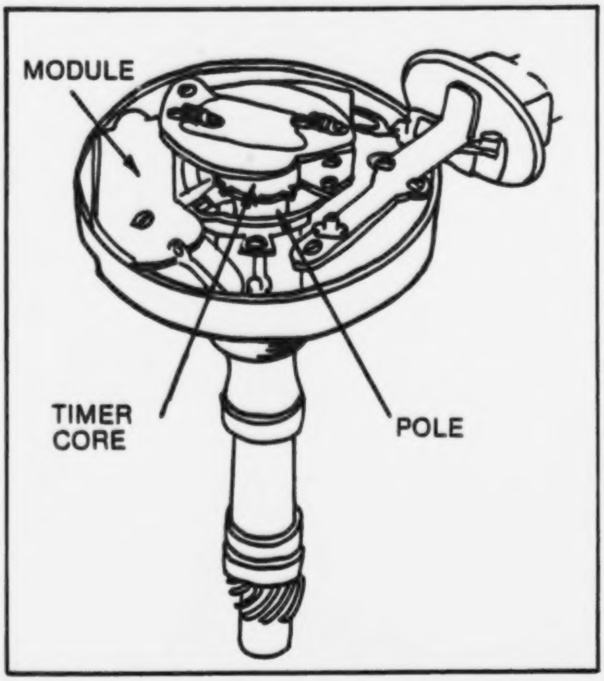
6. The ignition coil produces the high voltage that eventually goes to the spark plugs.



7. The ignition sequence begins when someone cranks the engine.

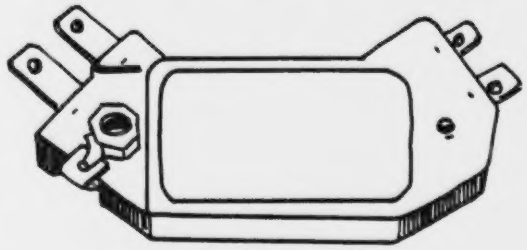
8. The timer core shaft rotates and moves the timer core teeth toward the pole piece teeth of the pick-up coil.

   The movement of the timer core teeth, along with the pick-up coil assembly, creates a low voltage in the pick-up coil and sends the voltage to the module.



9. The module receives the voltage from the pick-up coil. The voltage causes a transistor in the module to turn on.

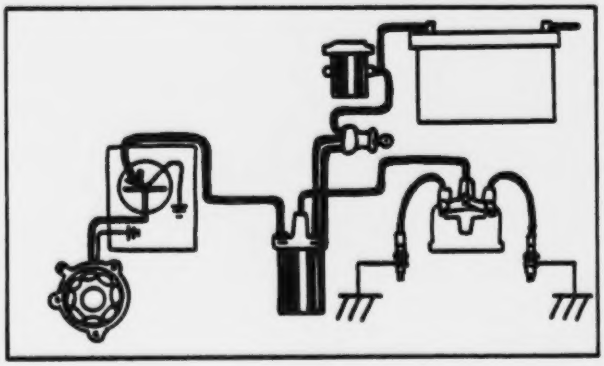
10. While the module is "on," current is allowed to flow in the ignition coil primary circuit. The flow creates an electro-magnetic field.



ELECTRONIC MODULE

11. As the timer core teeth move away from the pole piece teeth, the voltage produced in the pick-up coil changes polarity. (Its positive and negative poles are switched.)

12. When the polarity changes, the module turns the primary current off.

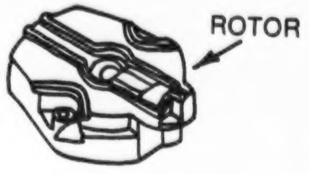


13. This sudden dropoff in the primary current causes the electromagnetic field to collapse.

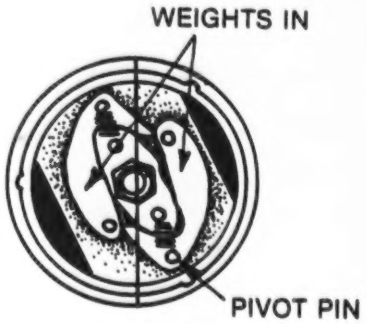
    The collapsing electromagnetic field cuts across the secondary winding of the ignition coil. This cut creates the high voltage needed to fire the spark plugs.

    (The process of creating high voltage in the ignition coil is called "electromagnetic induction.")

14. The high voltage then travels from the coil to the center terminal of the rotor. The rotor discharges the secondary voltage from the ignition coil to the distributor spark plug towers.

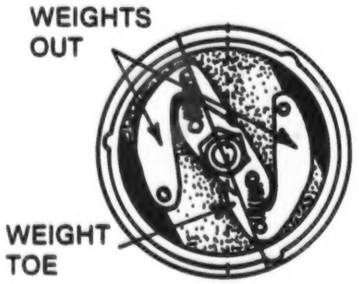


15. The centrifugal advance mechanism makes the spark occur in the cylinder earlier by moving the rotor and timer core in the direction the distributor shaft is turning.



NO ADVANCE

The early firing of the spark plug is caused by "centrifugal advance" (sometimes called "mechanical advance"). Centrifugal advance ensures that the engine creates maximum power at high RPM's.

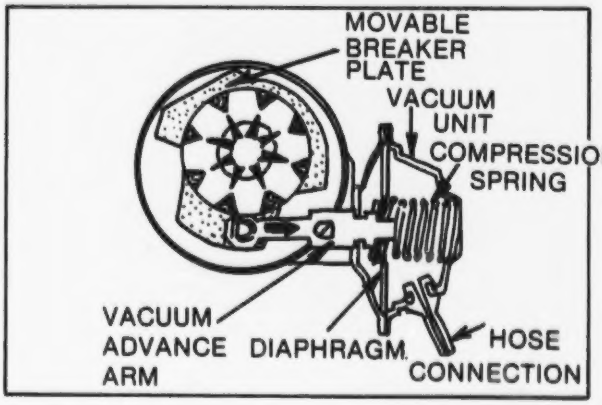


FULL ADVANCE

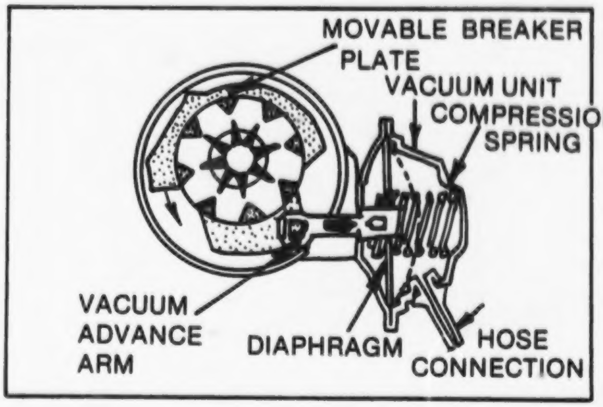
As the engine goes faster, weights in the advance mechanism move out and push the rotor and timer core forward.

16. The vacuum advance makes the spark occur in the cylinder even earlier than the centrifugal advance, by moving the pick-up coil assembly.

    The movement of the pick-up coil is caused by a vacuum created in the carburetor. The vacuum moves a diaphragm and mechanical linkage connected to the pick-up coil.


MOVABLE BREAKER PLATE
VACUUM UNIT
COMPRESSION SPRING
VACUUM ADVANCE ARM
DIAPHRAGM
HOSE CONNECTION

17. The vacuum advance mechanism makes the spark occur earlier in the cylinder under light loads and not as early under heavy loads.


MOVABLE BREAKER PLATE
VACUUM UNIT
COMPRESSION SPRING
VACUUM ADVANCE ARM
DIAPHRAGM
HOSE CONNECTION

DO SKILL SHEET 1

SKILL SHEET 1

Directions: Complete the following statement with one of the words or phrases listed below. If you are unsure of an answer, look back at the text for help.

centrifugal
induction
rotor
control module
low
timer coil
high
pick-up coil
vacuum

1. The _______________ is the electronic ignition system component that distributes a spark to the correct coil terminal in the distributor cap.

2. The _______________ is the electronic ignition system component that turns the ignition coil on and off.

3. ____________________________ is the term used to describe the creation of high voltage in the ignition coil.

4. The _______________ advance is needed to ensure maximum power at higher RPM's.

5. The pick-up coil develops _______________ voltage.

C. Steps of Procedure for Trouble-Shooting the High Energy Ignition System (HEI)

1. Put on your safety glasses.

2. Gather the following tools and materials:

   Test light
   Voltmeter
   Hand tools
   Specification manual
   Ohmmeter

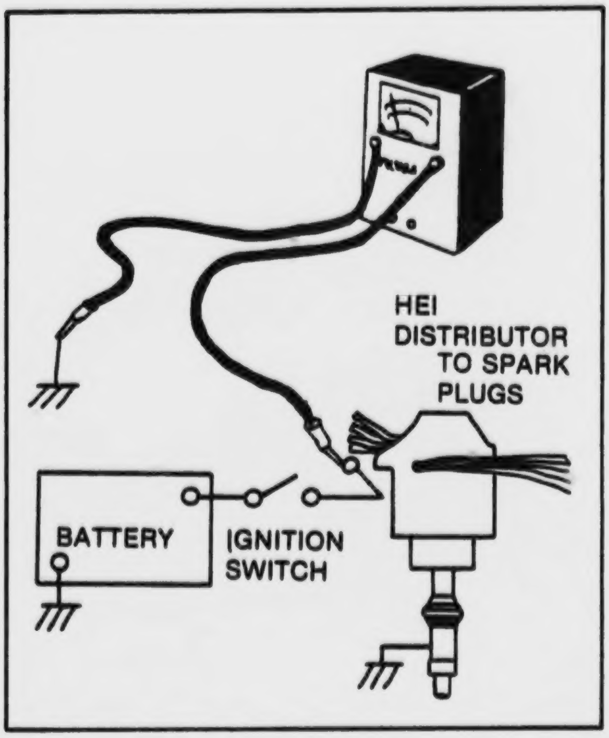
3. The two most common complaints that point to problems in the ignition system are:

   - "The engine will not start."
   - "The engine starts but runs rough."

We will now study test procedures that allow you to deal with these complaints and pinpoint the problems behind the complaints.

D. Trouble-Shooting When the Engine Will Not Start:

1. Connect one voltmeter lead to the battery terminal lead on the distributor.



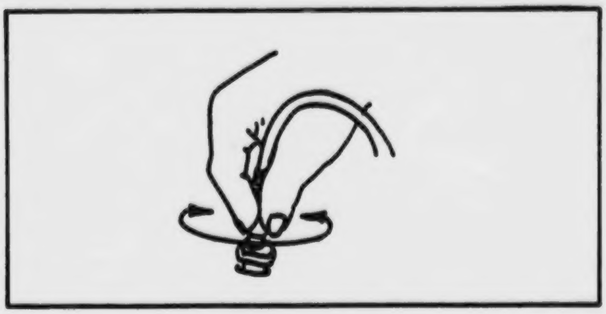
2. Connect the other voltmeter lead to ground.

3. Turn the ignition switch to the ON position.

4. Check the voltage. If the meter shows zero voltage, repair the open circuit between the battery terminal and the battery.

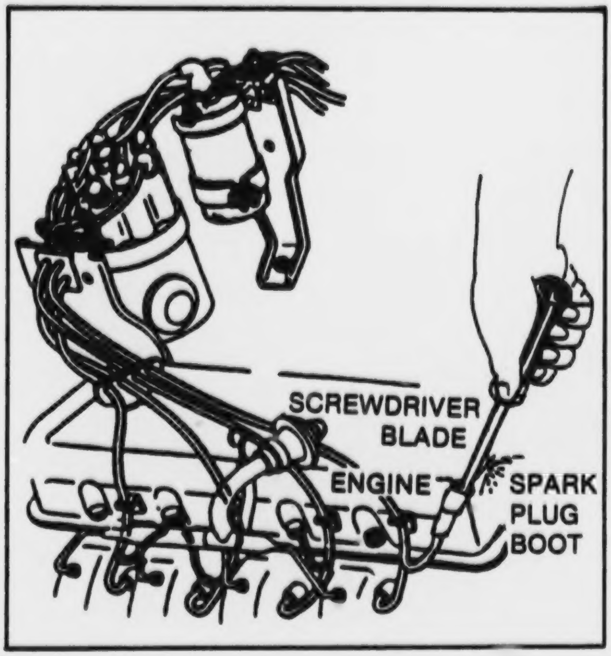
5. Check to see if the meter is reading battery voltage.

6. If the meter is reading battery voltage, the primary input signal is O.K.



7. Lightly twist the spark plug boot to loosen and remove the lead from the plug.

8. Put a Phillips screw driver into the spark plug boot to the contact lead and hold the blade 1/4" from a dry area of the engine block as you crank the engine.



9. Check to see if sparking occurs. If you get a spark, the trouble is not in the ignition system.

10. If no spark occurs, follow the procedure in section "E" ("component checks") in this unit. If a spark occurs, the following systems and components should be checked. They can be reasons for an engine not starting or running rough:

    - inoperative fuel system
    - restricted air intake system
    - bad spark plug cables
    - faulty timing system
    - fouled spark plugs
    - engine's mechanical condition

    Follow the procedure in section "F" in this unit ("Troubleshooting when the Engine Starts but Runs Rough").

DO ACTIVITY SHEET 1

HEI SYSTEM TESTS

ACTIVITY SHEET 1

1. See your instructor to get a car that needs its HEI system tested.
2. Review the procedure outlined in this unit and in the appropriate service manual for the car.
3. Secure the tools and equipment needed.
4. Complete the test procedure. **WEAR SAFETY GLASSES!**
5. Record the results of the test.
   a. What is the voltmeter reading at the battery terminal lead on the distributor?

      ____

      O.K. ☐ Not O.K. ☐

   b. Did the spark jump the 1/4" gap between the screwdriver and the engine block?

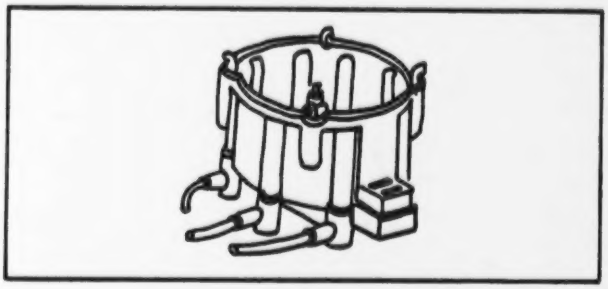
      Yes ☐ No ☐
      O.K. ☐ Not O.K. ☐
6. Put away your tools and equipment and clean up the work area.

E. Component Checks

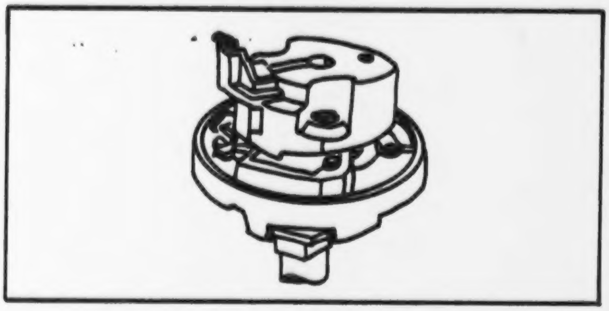
(Because of limitations on time and space, the information given deals with the General Motors HEI system. Ask your instructor for information on other car makes.)

Component checks are made on the cap, rotor, ignition coil, pick-up coil and electronic module.

1. Remove the cap and coil assembly.



2. Remove the rotor.



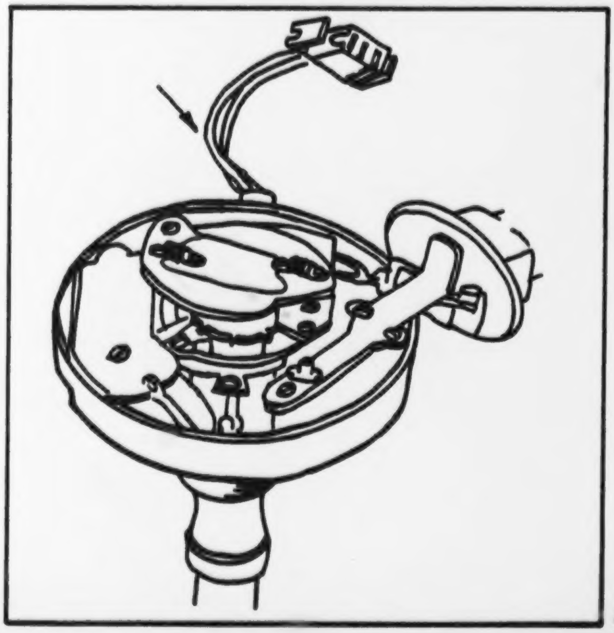
3. Carefully inspect the inside of the cap and rotor for spark-over, carbon tracking or other damage.

   Replace the cap or rotor if you find any problems.

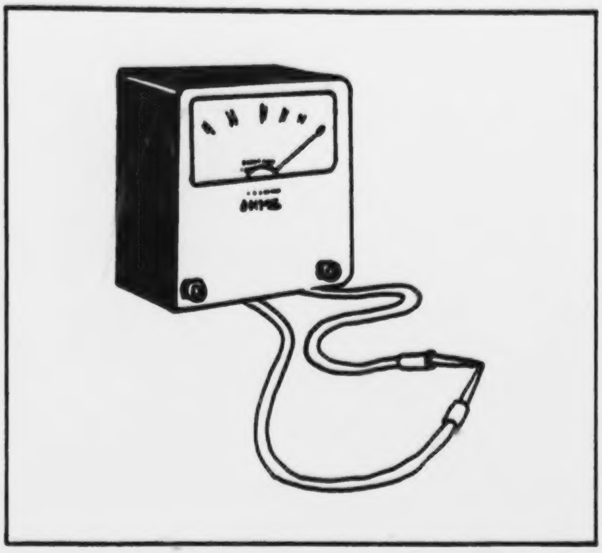
4. Carefully inspect the wiring harness that connects the distributor cap to the ignition module.

   If the condition of the wires is questionable, use an ohmmeter to check for continuity.

   If you find problems in the wiring harness, replace it.



5. Use an ohmmeter to check the ignition coil primary circuit.

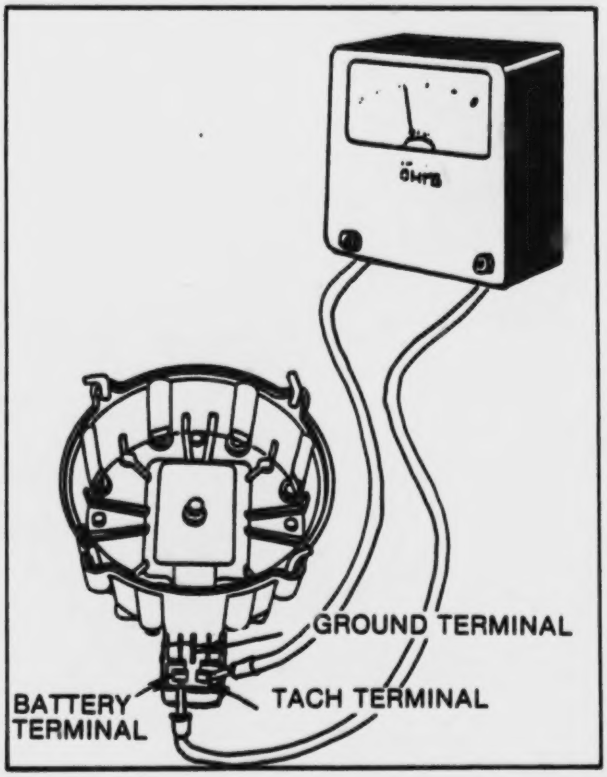


   a. Calibrate the ohmmeter on the low scale.

   b. The ohmmeter should be connected between the battery terminal and the "TACH" terminal.

      The meter should register between .4 and 1.0 ohms.

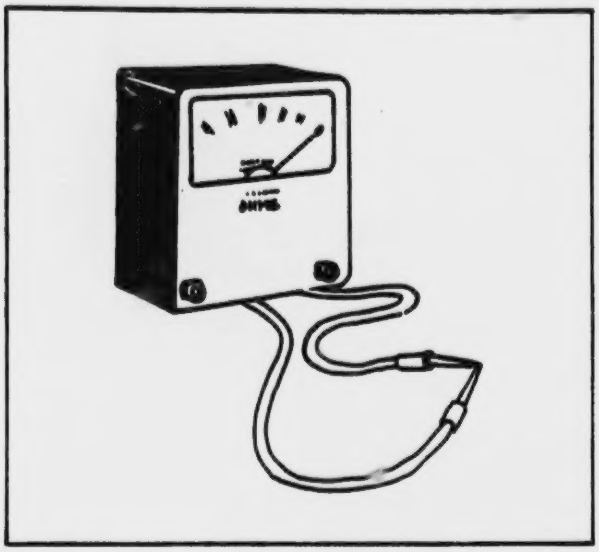
      If the meter reading is not in the above range, replace the coil.


OHMS
GROUND TERMINAL
BATTERY TERMINAL
TACH TERMINAL

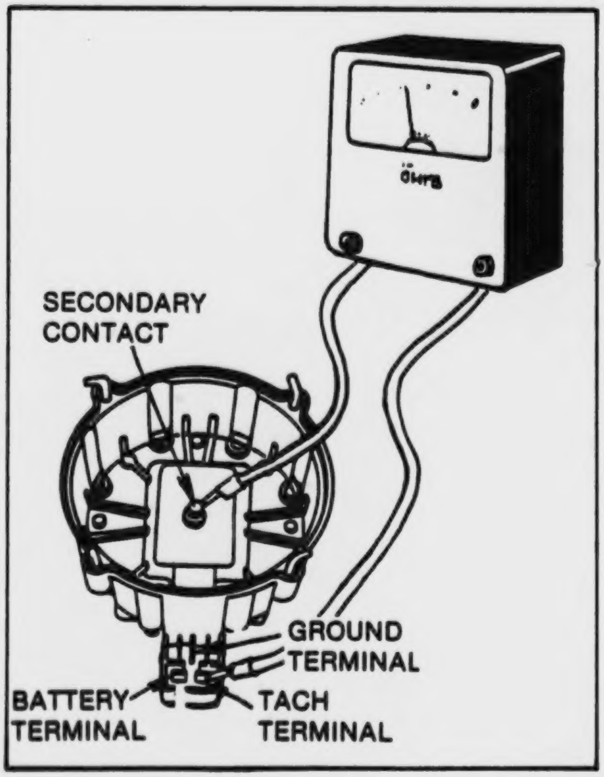
   c. Next, connect the ohmmeter between the ground and battery terminals.

      If the reading is other than infinity (no reading), replace the coil.

6. Use an ohmmeter to check the ignition coil secondary circuit.



   a. Calibrate the ohmmeter on the highest scale.


OHMS
SECONDARY CONTACT
GROUND TERMINAL
BATTERY TERMINAL
TACH TERMINAL

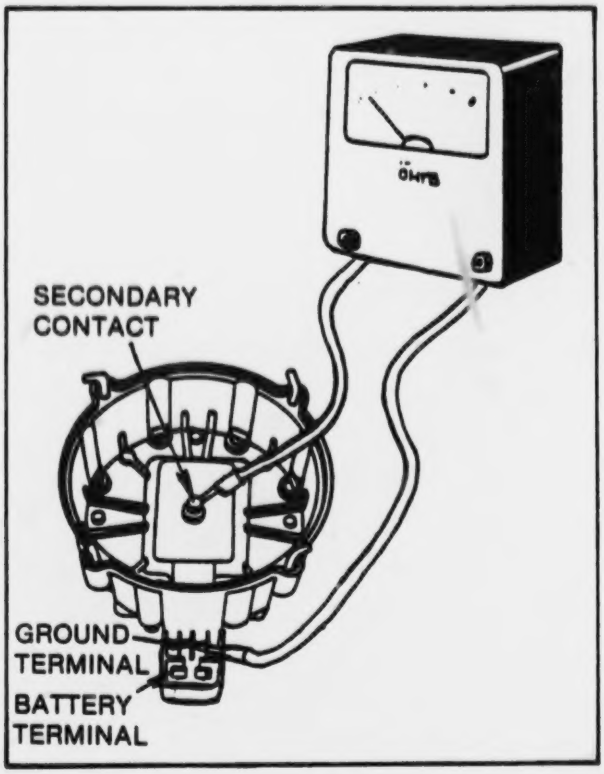
   b. Connect one ohmmeter lead to the coil secondary contact (carbon brush).

   Connect the other lead to the "TACH" terminal.

   - Resistance between the "TACH" and secondary terminals should be 6,000 to 30,000 ohms on 1974-1975 coils (2-wire), infinity on 1976-1988 coils (3-wire) and 6,000 to 60,000 ohms on 1977-1988 coils (2-wire).

c. Connect one ohmmeter lead to the coil secondary contact (carbon brush). Connect the other lead to the ground terminal.

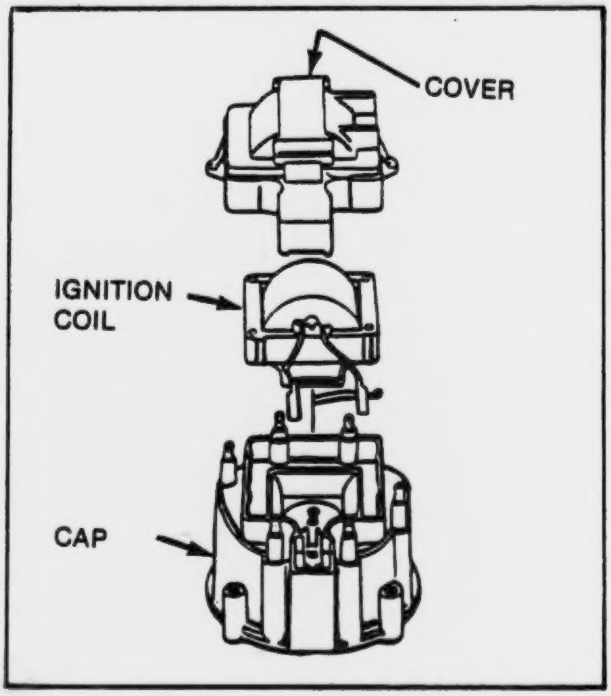
- Resistance between ground and secondary terminals should be infinity on 1974-1988 coils (2-wire) and 6,000 to 30,000 ohms on 1976-1979 and 3-wire coils.
- On 1980-1986 models, the coil should only be suspected as the cause of trouble if resistance is infinite at both the "TACH" and ground terminals.


OHMS
SECONDARY CONTACT
GROUND TERMINAL
BATTERY TERMINAL

d. If the readings are out of the specifications, the coil should be removed from the cap and retested.

If the coil tests O.K., replace the carbon button and spring.

If the coil does not test O.K., replace the coil.


COVER
IGNITION COIL
CAP

DO ACTIVITY SHEET 2

HEI SYSTEM TESTS

ACTIVITY SHEET 2

1. See your instructor to get a car that needs its HEI system tested.
2. Review the procedure outlined in this unit and the appropriate service manual.
3. Secure the tools and equipment needed.
4. Complete the test procedure. **WEAR SAFETY GLASSES!**
5. Record the results of the test.

   a. Visual inspection of the cap and rotor:
   Record results ____________________
   ____
   O.K. ☐ Not O.K. ☐

   b. Visual inspection of the wiring harness between the cap and ignition module:
   Record results ____________________
   ____
   O.K. ☐ Not O.K. ☐

   c. Ohmmeter test of the wiring harness between the cap and ignition module:
   Record results ____________________
   ____
   O.K. ☐ Not O.K. ☐

d. Ohmmeter check of coil primary circuit:

(1)Battery terminal to TACH terminal:
Specification __________
Results __________
O.K. ☐ Not O.K. ☐

(2)Battery terminal to ground terminal:
Specification __________
Results __________
O.K. ☐ Not O.K. ☐

e. Ohmmeter check of coil secondary circuit:

Year of car __________
Number of wires in cap to module harness __________

(1)Secondary contact to TACH terminal
Specifications __________
Results __________
O.K. ☐ Not O.K. ☐

(2)Secondary contact to ground terminal
Specifications __________
Results __________
O.K. ☐ Not O.K. ☐

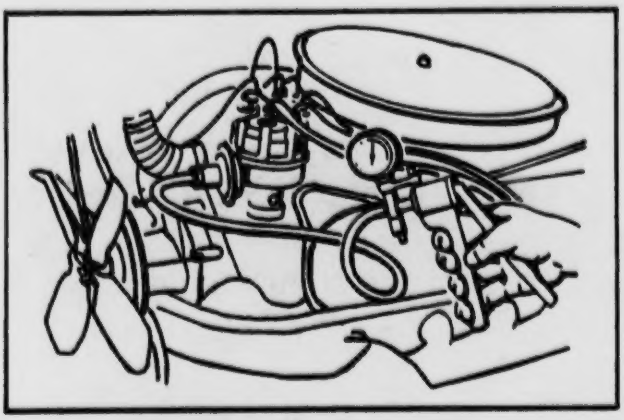
f. Coil test
O.K. ☐ Not O.K. ☐

6. Put away your tools and clean up the work area.

7. Test the vacuum advance

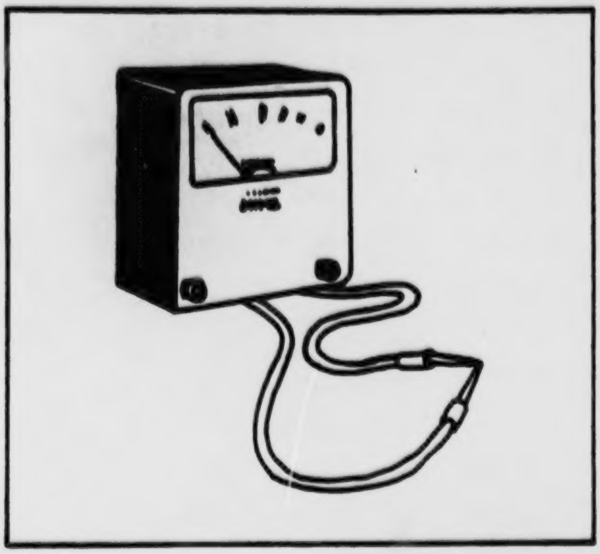
   Connect a vacuum pump to the vacuum advance to see if the vacuum diaphragm will hold vacuum.

   If this test shows the vacuum unit is not working, replace the unit.



8. Test the pick-up coil.

   Note: Be sure to work the vacuum advance several times during each test. Use the vacuum pump as a source.

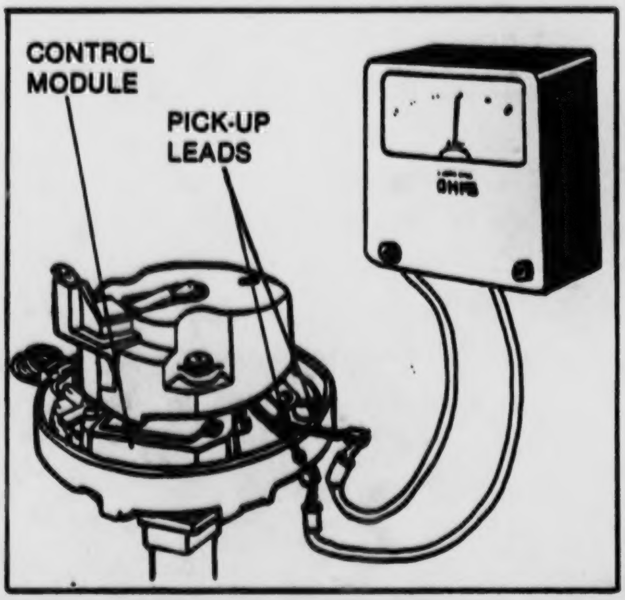


(Resistance test)

a. Calibrate an ohmmeter on the middle scale.

b. Disconnect the pick-up coil leads from the control module and connect the ohmmeter leads to the pick-up coil.

   The reading should be between 500 and 1,500 ohms. If not, the pick-up coil assembly should be replaced.



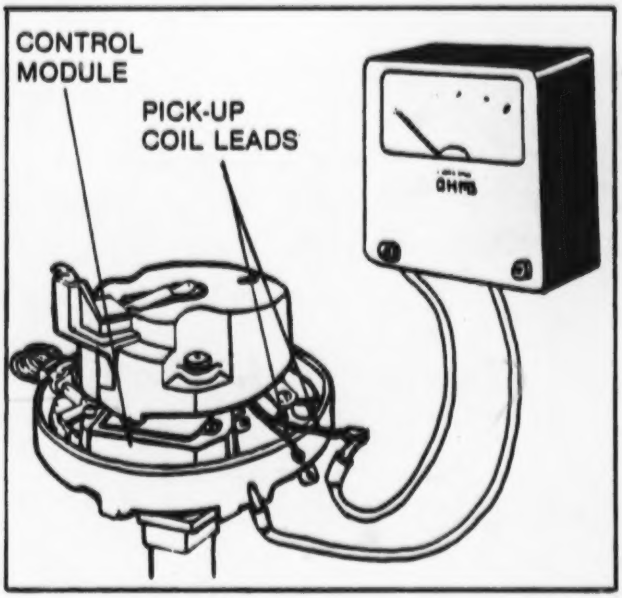
(Short circuit test)

a. Calibrate an ohmmeter on the middle scale.

b. Disconnect the pick-up coil leads from the control module.

c. Connect one ohmmeter lead to either of the two pick-up leads.

d. Connect the other ohmmeter lead to the distributor housing. The reading should be infinity (no reading). If not, replace the pick-up coil assembly.



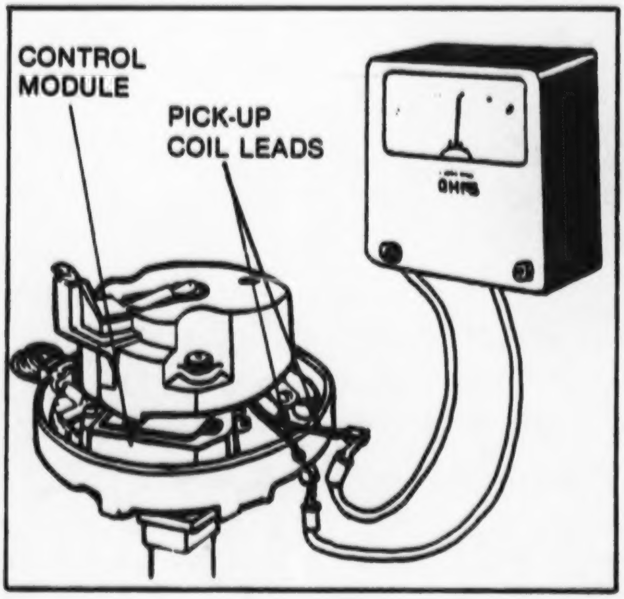
(Voltmeter test)

a. Set voltmeter to low AC scale (low DC scale can be used, but voltmeter will only pulsate and won't give actual reading).

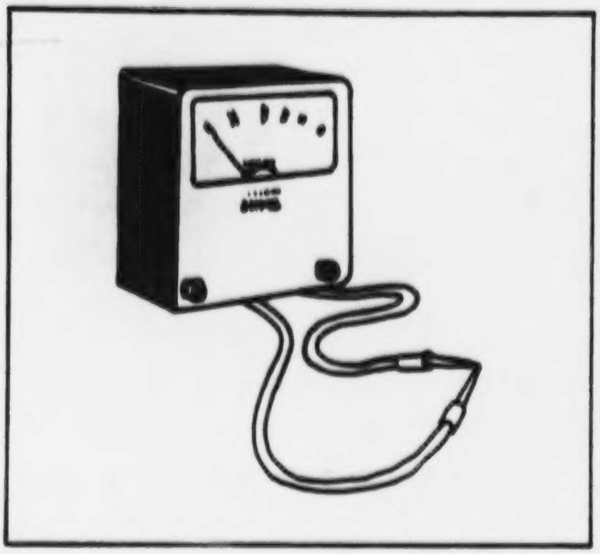
b. Disconnect the pick-up leads from the module.

c. Connect the voltmeter leads to the leads of the pick-up coil.

d. Rotate the distributor (by hand or crank the engine over). An AC voltage of 1-2 volts should be reached, or, on DC, the needle should wiggle.



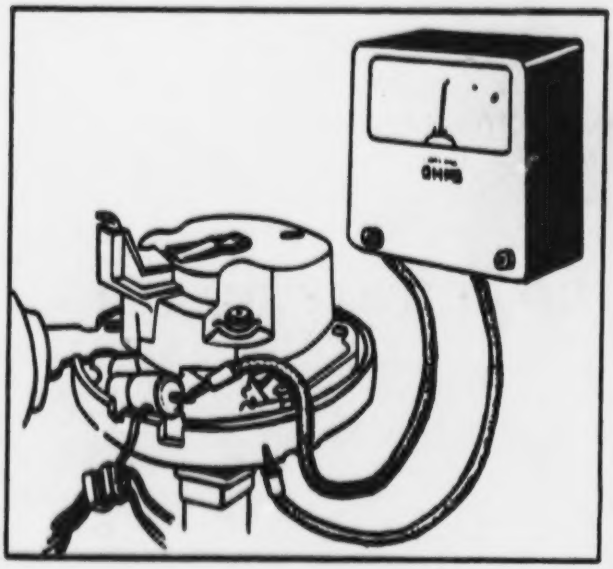
311



9. Use an ohmmeter to test the capacitor for shorts.

a. Calibrate the ohmmeter using the highest scale.

b. Disconnect the capacitor. Place one ohmmeter lead on the capacitor terminal.

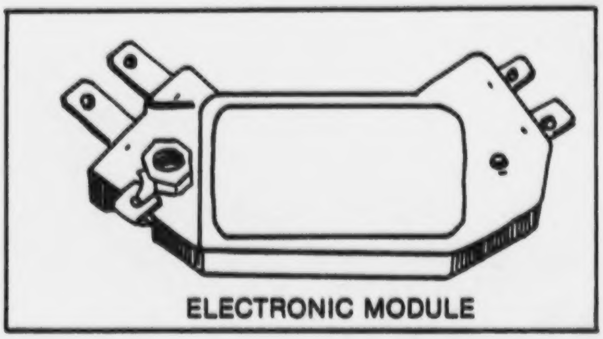


c. Place the other ohmmeter lead on a good ground.

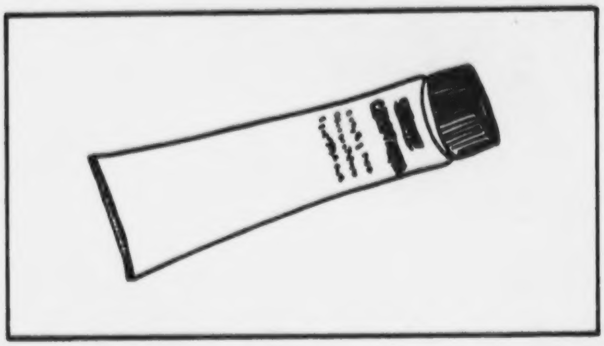
The meter might move slightly and return to infinity.

If the slightest amount of continuity is measured, replace the capacitor.

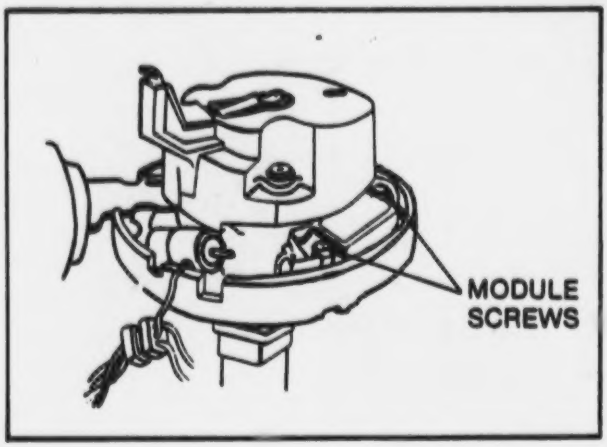
10. Replace the control module.



- If the system still doesn't work or doesn't work properly, and all the electrical connections and wires have been checked, replace the control module.



- When replacing the control module, be sure to apply a thin film of silicone grease to the surface of the control module that sits on the distributor housing.



- Don't over-tighten the screws that hold the control module to the distributor housing.

(Some technicians call the control module an "ignition module.")

DO ACTIVITY SHEET 3

HEI SYSTEM TESTS

ACTIVITY SHEET 3

1. See your instructor to get a car that needs its HEI system tested.

2. Review the procedure outlined in this unit and in the appropriate service manual for the car.

3. Secure the tools and equipment needed.

4. Complete the inspection procedure. **WEAR SAFETY GLASSES!**

5. Record the results of the tests.

    a. Vacuum advance unit:
    Record results ____________________

    ____

    O.K. ☐ Not O.K. ☐

    b. Pick-up coil:
    (1)Resistance test
    Record results ____________________

    ____

    O.K. ☐ Not O.K. ☐

    (2)Short circuit test
    Record results ____________________

    ____

    O.K. ☐ Not O.K. ☐

(4)Capacitor test
Record results ____________________

____

O.K. ☐ Not O.K. ☐

Should the ignition module be replaced?

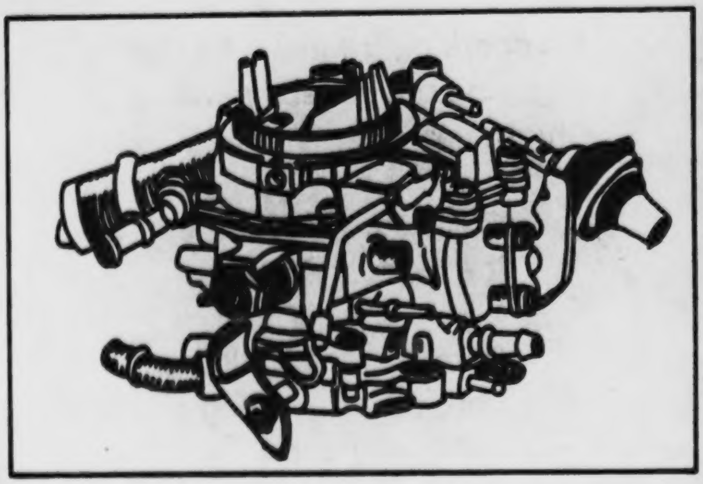
Yes ☐ No ☐

Explain your answer ____________________

____

6. Put away your tools and equipment and clean up the work area.

F. Troubleshooting When the Engine Starts but Runs Rough

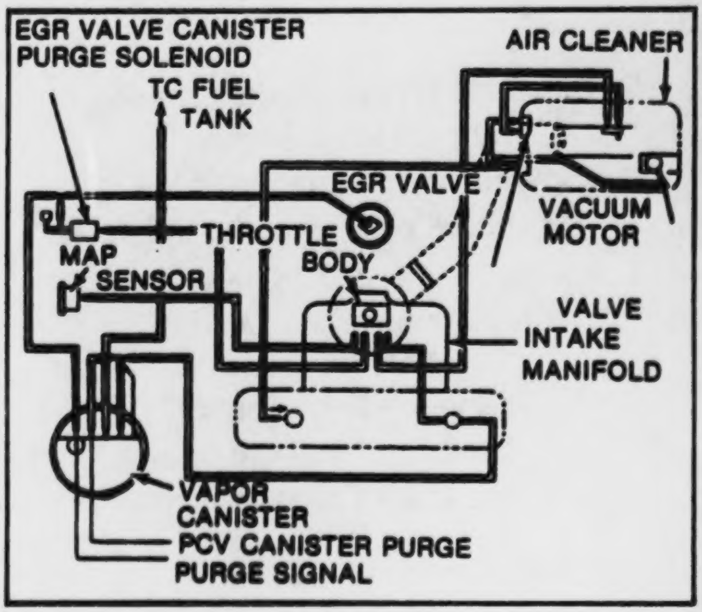


1. Be sure the proper fuel/air ratio is being delivered by the carburetor and that the fuel injection system is working properly.

   Delivery of improper fuel could account for at least part of the engine roughness.

   Possible fuel system problems that could be causing the engine to run rough include:
   - a clogged air filter,
   - a clogged fuel filter,
   - a dirty carburetor
   - or dirty injector(s).

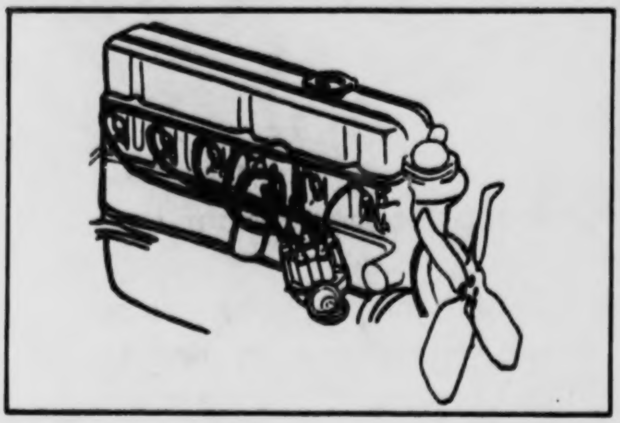
NOTE: Fuel system service is not covered in this unit. See your instructor for more information.


EGR VALVE CANISTER
PURGE SOLENOID
TC FUEL
TANK
AIR CLEANER
EGR VALVE
VACUUM
MOTOR
THROTTLE
BODY
MAP
SENSOR
VALVE
INTAKE
MANIFOLD
VAPOR
CANISTER
PCV CANISTER PURGE
PURGE SIGNAL

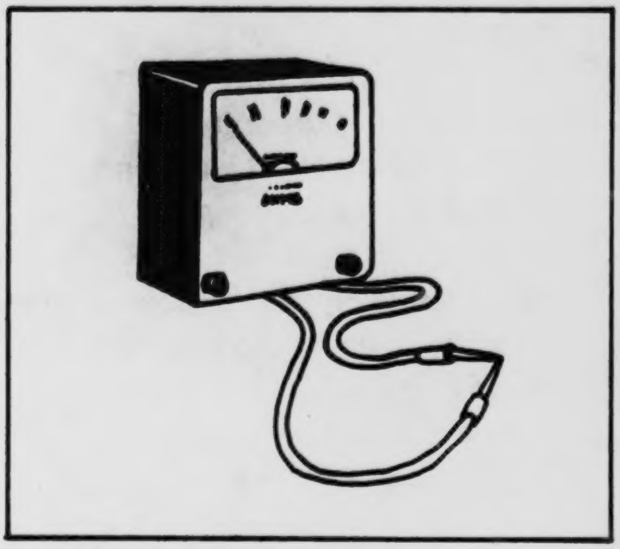
2. Check all vacuum hoses for leakage.

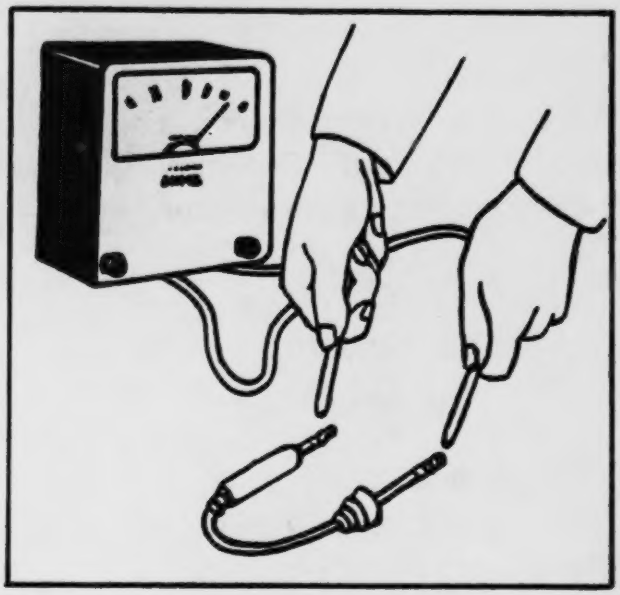
   Don't stop after this step even if you find a leak. The leak may be only part of the problem.

3. Visually inspect and listen for sparks jumping to ground.

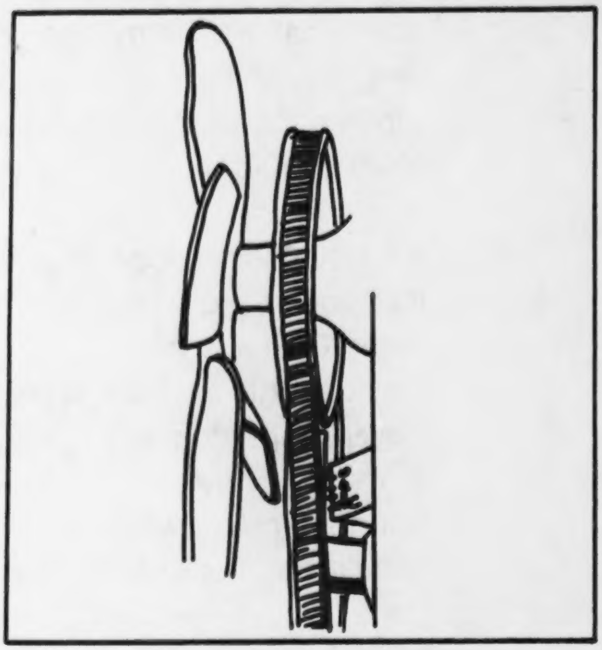


4. If a spark plug wire looks like it might be bad, check it with an ohmmeter.
   a. Calibrate the ohmmeter on the highest scale.
   b. Remove the spark plug wire from the spark plug and distributor cap.
   c. Connect the ohmmeter in series with the spark plug wire.
   d. Use an appropriate service manual to determine the current resistance of the spark plug wires for the car you are working on.
   e. If the reading is out of specification (high or low), the spark plug wire should be replaced.





317



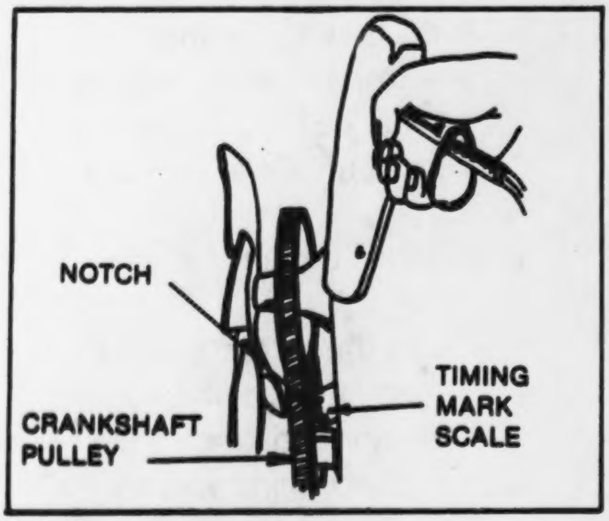
5. Check the initial timing.

    a. Read the manufacturer's emmissions decal or use the service manual to find the proper procedure.

    b. Clean and mark the timing lines.

    If the timing isn't set properly, the engine will run rough.

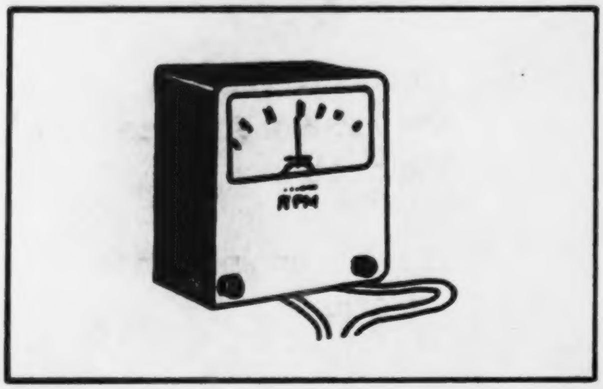
    c. Start the engine and measure the timing.



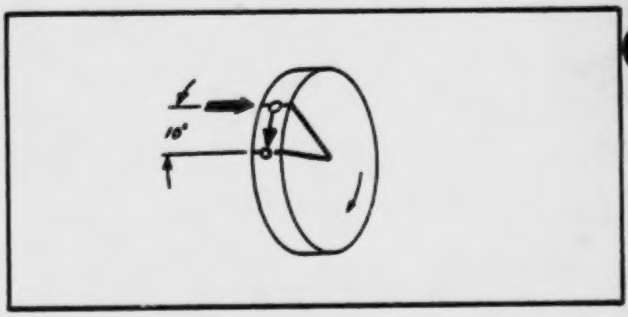
6. Check the centrifugal advance.

    a. Use the proper service manual for the correct centrifigal advance timing curve for the engine you are working on.

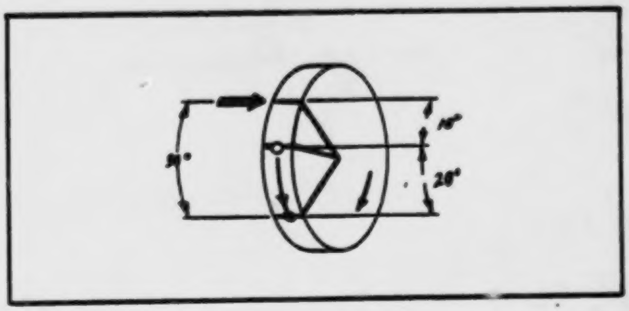
    b. Start the engine and increase the RPM to the proper speed to measure the timing.



c. If the reading is out of specification, the mechanical weights, springs and weight pins on top of the distributor shaft should be checked.



d. If a visual inspection shows that one or more of the centrifugal advance components are bad, replace the appropriate parts.

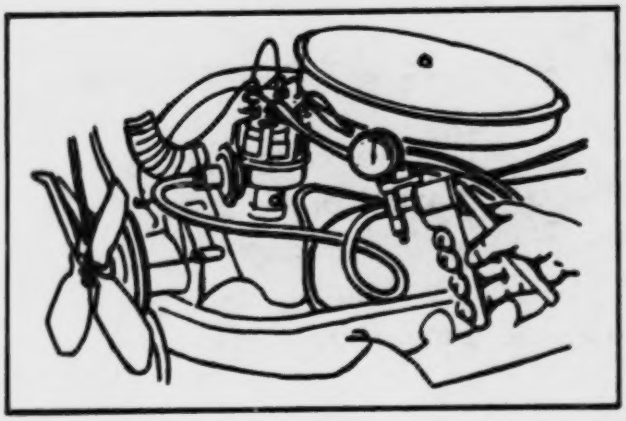


- Springs and/or weights should be changed in pairs.

- If the weight pins on top of the distributor shaft are worn, a bushing repair kit must be installed, or the shaft must be replaced.

7. Check the vacuum advance.

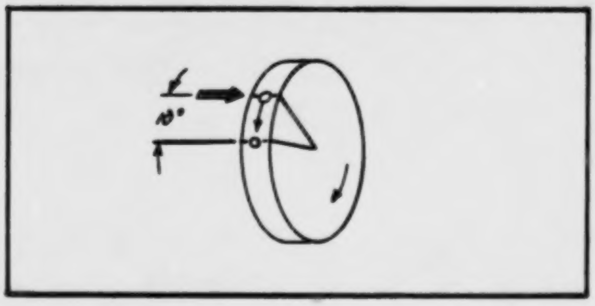
   a. Use the proper service manual to get the current vacuum advance timing curve for the engine you are working on.



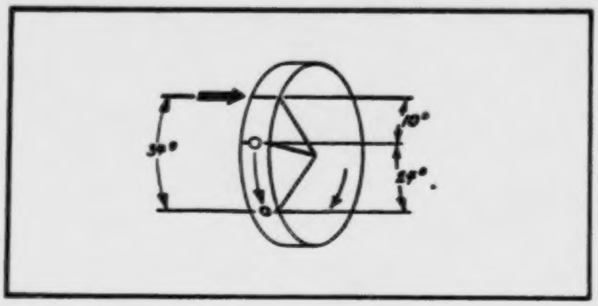
   b. Connect a vacuum pump to the vacuum advance unit on the distributor.

   c. Start the engine and let it run at idle.

d. Increase the vacuum to the proper level and measure the timing.



e. If the reading is not within the specifications, the vacuum advance unit, the linkage and the pick-up coil should be visually inspected.

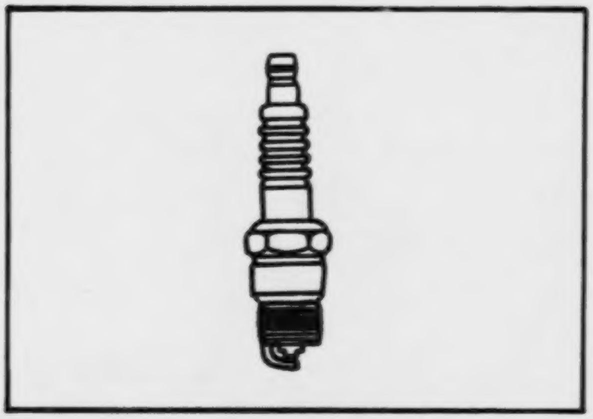


f. If one of these main components looks like it is causing the problem, it should be serviced or replaced.

NOTE: Distributor service and detailed timing information is not given in this unit. See your instructor for more information.

8. Remove all spark plugs and check for defects that could cause the engine to run rough, such as:

- Improper gap
- Fouling
- Cracked insulators (both inside and out)



Replace any worn or defective spark plugs.

9. Check for mechanical problems in the engine.

NOTE: Engine service is not covered in this unit. See your instructor for more information.

10. If no defects are found after the first nine checks, check for a faulty ignition system component by following the procedure under Section "E" ("component checks") in your manual.

DO ACTIVITY SHEET 4

HEI IGNITION TESTS

ACTIVITY SHEET 4

1. See your instructor to get an HEI-equipped car that starts but runs rough.

2. Review the procedure outlined in this unit and in the appropriate service manual for the car.

3. Secure the tools and equipment needed.

4. Complete the inspection procedure. **WEAR SAFETY GLASSES!**

5. Record the results of the test.
   a. Does the fuel system work effectively?
   Yes ☐ No ☐
   Explain your answer ____________________
   ____

   b. Check for vacuum leaks and make the needed repairs.
   O.K. ☐ Not O.K. ☐

   c. Spark plug wire condition (ohmmeter reading):
   Specification ___________
   Number 1 cylinder ___________
   Number 2 cylinder ___________
   Number 3 cylinder ___________
   Number 4 cylinder ___________
   Number 5 cylinder ___________
   Number 6 cylinder ___________
   Number 7 cylinder ___________
   Number 8 cylinder ___________
   O.K. ☐ Not O.K. ☐

d. Perform a timing check

CAUTION: For automatic transmission cars, make sure the shift lever is in "P" (Park) and the emergency brake is on. For manual transmission cars, make sure the shift lever is in neutral and the emergency brake is on.

Initial timing
 Specification __________
 Results __________

Centrifugal advance
 Specification __________
 Results __________

Vacuum advance
 Specification __________
 Results __________
 O.K. ☐ Not O.K. ☐

Explain your answer ____________________

____

e. Check the spark plugs.
 Record the results ____________________

____

O.K. ☐ Not O.K. ☐

f. Check the mechanical condition of the engine.
 Record the results ____________________

____

O.K. ☐ Not O.K. ☐

6. Put away your tools and equipment and clean up the work area.

UNIT REVIEW

1. The pick-up coil fires the spark plugs.

TRUE FALSE

2. The ignition module controls the

a. pick-up coil current flow
b. mechanical advance
c. ignition coil current flow
d. vacuum advance

3. Vacuum advance changes as __________ changes.

a. vehicle speed
b. engine load
c. engine RPM
d. spark plug gap

4. Which motor is used to check the ignition coil?

a. ammeter
b. ohmmeter
c. voltmeter
d. kilowattmeter

5. When replacing the control module, you put ________________ between the ignition coil and distributor housing.

a. nothing
b. an insulator
c. a carbon button
d. silicone grease

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Put on his/her safety glasses			
2. Gathered necessary tools and equipment			
3. Used a voltmeter correctly			
4. Used an ohmmeter correctly			
5. Performed the diagnostic tests for an engine that "doesn't start"			
6. Performed the diagnostic tests for an engine that "starts, but runs rough"			
7. Took apart a distributor and checked the components			

Should move on ☐

Should repeat this unit ☐

______________________________ ______________________________

Student Signature/Date Instructor's Signature/Date